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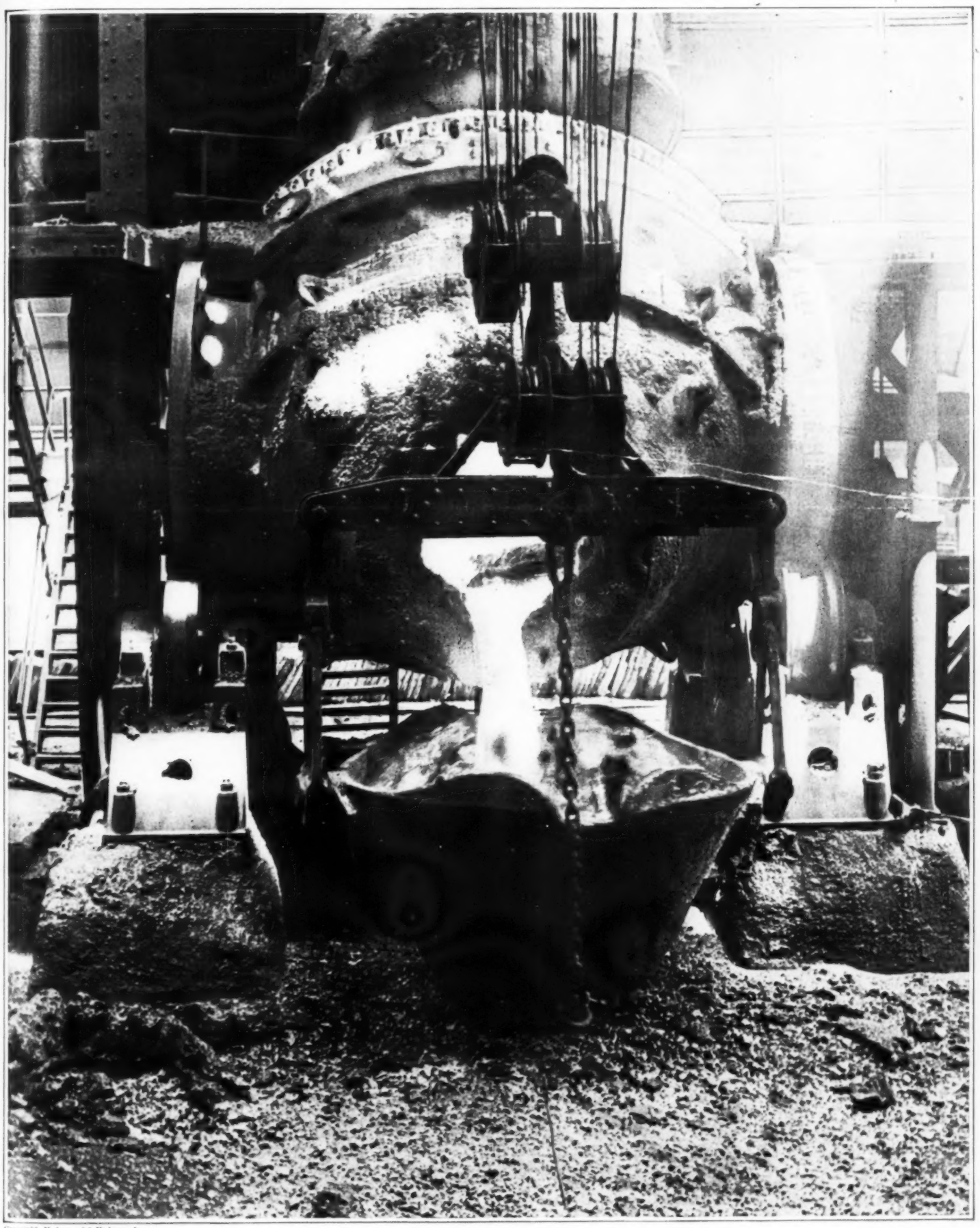

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Pouring molten copper from a converter into a ladle for casting plates

THE PRODUCTION OF COPPER [See Page 72]

The Rôle of Selection in Evolution—I*

An Agency for the Elimination of Variations

W. E. Castle, Bussey Institution

Up to the year 1900 those who believed in organic evolution almost without exception believed in selection as its efficient cause. Then came a period of doubt, inaugurated by DeVries' Mutation Theory and strongly supported by Johannsen's Pure Line Theory. In the minds of many biologists at the present time selection is an obsolete agency in evolution and an adequate explanation of evolution is to be found only in mutation and pure lines. I believe this to be a mistaken view, not because mutation and pure lines are false, but because their applicability is very limited as compared with the broad field of organic evolution. To universalize them is to hide the world by holding a small object close to the eye. For even if we concede the strongest possible claim for mutation as an agency in evolution, viz., that it produces all new and heritable variations, it is still unable to produce evolution without the aid of selection. The production of new variations produces no racial change unless those variations persist, but their persistence depends wholly upon selection. This is admitted by DeVries, the author of the mutation theory, but overlooked by many of those who have adopted the term mutation, as a scientific shibboleth.

But it is idle to enter upon a discussion of either selection or mutation without carefully defining these terms, since both are often used quite ambiguously, the latter in particular being used in several different senses, and so being a cause of misunderstanding where no genuine difference of view exists.

Ever since DeVries' original attack in 1900, it has become increasingly common among biologists to refer with disrespect to "Darwinian selection." But Darwin understood by selection any agency which would cause one organism to survive rather than another, and it is not clear that any theory of evolution can dispense with such an agency. Since more organisms are born than can survive, some must perish. In a state of nature, that is, in a state of affairs not actively controlled by man, those creatures survive which are best adapted to their surroundings. This is what Darwin meant by "natural selection." Among organisms under the immediate control of man, as the cultivated plants and domesticated animals, where the determination of what individuals shall become parents rests with man, Darwin recognized the occurrence of "artificial selection."

Any legitimate attack on Darwin's views of selection must deal either with natural selection or with artificial selection. But when "Darwinian selection" is mentioned as a term of reproach, the attack is really directed neither against natural selection nor against artificial selection, nor against any other conceivable form of selection, but against one of Darwin's views as to the nature of variability. Darwin recognized two sorts of heritable variations, (1) those which are purely quantitative, plus or minus, as compared with the prevailing racial condition, and (2) those which are wholly different from the prevailing condition. The former we may call "fluctuations," adopting the convenient term of DeVries. The latter Darwin often called "sports." Bateson has called them discontinuous variations and DeVries calls them mutations. Darwin believed that evolution might result either from the systematic and repeated selection of fluctuations or from the propagation of sports. DeVries doubts whether the systematic selection of fluctuations amounts to much in an evolutionary way, and Johannsen has denied to it any evolutionary effect whatever, on the ground that fluctuations are not inherited. Darwin assigned to the selection of fluctuations a major part in evolution, DeVries assigned to it a minor part, and Johannsen allows it no part in evolution. As regards sports, Darwin assigned to their selection a minor part in evolution (chiefly among cultivated plants and domestic animals); DeVries ascribed to a particular kind of sports (his "mutations") a major part in evolution; and Johannsen ascribes an exclusive part in evolution to a type of variation which would include both Darwin's sports and DeVries' mutations and then some. Johannsen has indeed made a new classification of variations which is both logical and sound, but which has resulted in some confusion owing to efforts to combine it with earlier classifications. He classifies variations into those which are inherited (genotypic) and those which are not inherited (phenotypic). No objection can be made to this classification except that it raises new difficulties and solves none. For how is one to distinguish a phenotypic from a genotypic variation? Only by trying them out. A variation which is inherited is genotypic; one which is not inherited is phenotypic. Since there is no other way than actual experiment by which to distinguish genotypic from phenotypic variations, we acquire only a new set of synonyms for inherited and non-inherited, a thing for which there was no urgent need.

Attempts to combine the classifications of variations made respectively by Darwin, by DeVries, and by Johannsen have resulted in serious confusion which is largely responsible for the apparently contradictory views held at present concerning selection. There really is no diversity of view concerning selection but only concerning the nature of the material that it acts upon (viz., variations).

To complicate the situation still further we have the discovery of Mendelian unit-characters which introduces a new uncertainty. Are these unit-characters fluctuations or sports? Do they arise solely by mutation or also by the cumulation of fluctuations? These are vital but perplexing questions. As matters stand concerning terminology, we have the term "sport," introduced by Darwin but now largely discarded, meaning any discontinuous, striking, suddenly appearing variation, known to be strongly inherited. Some of the examples cited by Darwin, such as the Ancon sheep, obviously involve Mendelian unit-characters.

The term mutant as used by DeVries signifies much the same as Darwin's term sport but involves a particular conception of the circumstances and manner of its origin which is not involved in Darwin's term. Some of DeVries' mutants of the evening primrose involve Mendelian unit-characters, as for example his dwarf mutant (*nanella*), while others such as *gigas* do not. The latter involves a double representation of every chromosome in the cell nucleus; the latter mutant involves the presence of a single extra chromosome. What chromosome changes, if any, are involved in other of DeVries' mutants which do not Mendelize is unknown. Morgan has shown that in Drosophila a unit-character change almost certainly involves a change in a definitely localized part of a single chromosome. But he applies the term mutation to each unit-character variation of Drosophila, of which he has observed over a hundred. Some of these are not at all striking, involving only a slight change in the shape, size, venation, or carriage of the wing, which might easily be overlooked by the ordinary observer. Many of them also fluctuate. Hence it is obvious that Morgan's use of the term mutation is very different from that of DeVries, its originator. To Morgan, mutation as illustrated in Drosophila is simply change by a unit-character. With this conception of mutation, Morgan attempts to combine the genotype conception of Johannsen. He regards unit-character variations as the only kind of genotypic variations and these as fluctuating (if at all) only through the interaction of other unit-characters, each one by itself being incapable of fluctuation.

It will be observed that as regards the term mutation, we have a very confused state of terminology which results in much discussion at cross-purposes, because persons using the same term have different things in mind.

But in this discussion, however confused its terminology, there are really involved two contrasted sets of general ideas, two alternative lines of explanation of evolutionary change, one favored by Darwin, the other offered as a substitute by DeVries and accepted by Johannsen and Morgan. We may briefly outline them as follows:

DARWIN

1. New types are for the most part created gradually.
2. New types are for the most part plastic.
3. One evolutionary change follows upon and is made possible by another.
4. Natural selection determines what classes of variations shall survive and, in consequence, what shall be the variable material subjected to selection in the next generation.
5. The further evolution of our domestic animals and cultivated plants (and of man himself) is to some extent controllable because we can by selection influence the variability of later generations.

DEVRIES

1. New types are created only abruptly.
2. New types are fully stable.
3. One evolutionary change has no necessary relation to another.
4. Natural selection determines only what classes of variations shall survive, and exercises no influence on the subsequent variability of the race.
5. Evolution is beyond our control as we discover and isolate variations.

These two sets of contrasted views remind us somewhat of the theological ideas of free-will and predestination respectively, which resemblance will account for the preferences of some biologists but will not prove which is right and which is wrong. This is wholly a matter for evidence. But what conclusion one reaches will depend much upon what sort of evidence he studies. Paleontology, geographical distribution, classification, and experimental breeding, all present evidence which must be weighed before a safe verdict can be framed.

Paleontology, the study of the actual historical records of evolution found in the rocks, indicates in the case of the most complete series of fossils, as for example of the horse, the camel, and the rhinoceros, that the evolution of these types was a gradual process, though of course their appearance in particular continents may have been abrupt, owing to migration. It indicates further that these and other types, when they first appeared, were plastic, and generalized and varied in many different ways, most of the variations later disappearing and leaving only a favored few lines of specialized survivors. It shows too that one variation paved the way to another. The five-toed horse first becomes four-toed, then three-toed, then one-toed. There is no mutation from five-toed to one-toed, nor from the size of a fox to that of a draft horse. As to natural selection, paleontology is silent, because the causes of extinction are unknown. But on the whole the weighty evidence of paleontology supports the view that evolution as an age long process has been gradual and progressive, not abrupt and unguided.

Geographical distribution and classification favor the same idea. Related species are most often found in contiguous territory. Species not closely related are commonly far separated in space or have been long separated in time. Nothing indicates that of two related species one has sprung suddenly from the other. They are not distinguished from each other, as a sport from its parent form, by some single Mendelian unit-character, but they differ morphologically by a large number of quantitative differences, and physiologically they differ to such an extent that frequently they will not interbreed when brought together even though their morphological differences are small, or they will produce sterile hybrids, or those of a blended, intermediate character. In all these particulars they show that they have not diverged by mutation, either in the sense of DeVries or in that of Morgan, but by a gradual progressive process.

Finally we come to the evidence from experimental breeding. Some say that this is the only legitimate evidence as regards the method of evolution because it alone is experimental. I should be the last to deny its importance because I have devoted much time to its pursuit in the firm conviction that it could yield valuable evidence, but frankness compels one to admit that this method of study, like all others, has limitations of its own. The experimental breeder can study a few successive generations with an intensiveness that is possible by no other method, but his glimpses of evolution at work are momentary as compared with the studies of the paleontologist. He can witness the production of new sorts but it is doubtful whether any man has witnessed the contemporary production of a new species, in the sense of the paleontologist and the student of geographical distribution. Evolution is undoubtedly at work all the time, but the breeder is not always in a position to say just what is happening. It takes a succession of views in a motion picture to show what objects are stationary and what are moving, and the breeder's view of the evolutionary process often fails to reveal which is which.

On the other hand, the experimental breeder, though he lacks perspective, is dealing with the actual material concerned in organic evolution. He can see and handle it and observe it change under his hands, as no other student of evolution can. But the changes which he observes taking place must be correctly interpreted if valid conclusions are to be reached concerning the general process of evolution. At present experimental breeders are divided in their views. The very same facts are interpreted by some as indicating an orderly progress toward definite end results, and by others as

*A lecture delivered before the Washington Academy of Sciences. From the Proceedings of the Academy.

nothing but haphazard unrelated chance occurrences. Just now the latter method of interpretation, embodied in the mutation theory, is very popular among experimental breeders, although it has few adherents among students of paleontology, classification, or geographical distribution.

The principal tools of the experimental breeder are hybridization and selection. All are agreed that hybridization (using the term in its broadest sense) is, in the hands of the breeder, a very potent agency in producing variability, upon which selection may then be brought to bear for the production of new or modified types. Lotsy even goes so far as to suggest that all genetic variability is the result of hybridization, but this is flatly disproved by observations of Johannsen who reports the occurrence of mutations in geneotypically pure lines of beans, as also by the remarkable series of variations observed by Morgan in an inbred race of Drosophila.

As regards the action of selection, the most widely divergent views are held by experimental breeders. The mutationists hold that it can do nothing but isolate variations which may sporadically put in an appearance or which may by hybridization be brought together into new combinations. Those who differ from them, and whom they call selectionists, maintain that selection can accomplish more than the mere isolation of variations because it can, by a series of selections, influence further variability. I confess myself an adherent of this at present somewhat unpopular view. I hold it, not because Darwin held it, not merely because paleontologists, systematists, and students of geographical distribution in general favor it, nor because DeVries and Johannsen have attacked it, but because the facts of experimental breeding, as I understand them, prove it.

For DeVries may be claimed the merit of having first systematically set about testing the effects of selection by actual experiment. His methodical selections for many years in succession of maize, buttercups, striped flowers, and four-leaved clover will long be remembered, but they fall far short of conclusiveness because they were not continued long enough to show whether selection had attained all that was attainable under existing variability or whether further variation in the direction of selection would occur, and because DeVries' cultures were not sufficiently guarded from hybridization which might conceivably influence the result. These necessary precautions were fully met by Johannsen, who in the case of beans, which are self fertilizing but show fluctuating variation in the size of the seed, proved that selection generation after generation in a particular direction may be without result, so far as any change in average seed size is concerned. Cases of this sort involve "pure lines," those which are devoid of genetic variation to any appreciable extent in the character studied, size of seed. But in other cases, as where Johannsen made his size selections from a field crop harvested from many different plants, he found that average size was influenced by selection, which he reasonably explains on the ground that the material from which selection was made consisted of a mixture of pure lines genetically distinct. The correctness of Johannsen's conclusion has been repeatedly verified in the case of other self-fertilizing plants such as wheat and oats. Attempts were at once made to generalize Johannsen's brilliant demonstration of the principle of pure lines in the following ways:

1. Since a line of beans long self-fertilized is devoid of genetic variation in seed size, self-fertilization, if long enough continued, will produce lines genetically pure as regards *all* characters. Selection cannot bring about modification of such pure lines. In respect to this generalization it may be said that it remains to be shown that beans are as devoid of genetic variation in other particulars as they are in seed size, which the argument assumes to be true. Further, if various pure lines of beans have come into existence by an evolutionary process (descent from a common ancestor, with modification) it is evident that differences must have arisen which did not originally exist. Suppose we grant Johannsen's (unproved) contention that such differences arise by mutation only. If they arise in this way (or in any other way whatsoever), selection can isolate them, and if they are at all frequent in occurrence, selection can be continuously effective in producing racial changes. It would all come down then to a question of how frequent mutations are in a particular case. Johannsen concedes their occurrence even in beans. It may well be that in some organisms they are commoner than in others and that in beans they happen to be particularly infrequent.

2. Johannsen's case has been further generalized to include *all* self-fertilizing organisms, which are supposed to fall automatically into pure lines (*i. e.*, those devoid of genetic variation) as regards all characters. This too requires proof, but has been found to be a safe working hypothesis in the case of cereals, tobacco, peas, and other economic crops, in the attempted improvement of which selection of fluctuations, unless preceded by hybridization may be regarded as a waste of time, for the reason that genetic variation is so rare under continuous self-fertilization that the breeder will obtain variation much more quickly by resorting to hybridization.

3. Further, it has been argued that if cross fertilization alone interferes with the automatic production of pure lines, then any organism which dispenses with fertilization altogether, reproducing asexually, must *ipso facto* constitute a pure line. Jennings sought to test out this conclusion by experiment. He selected size variations in Paramecium which reproduces by fission, with success in the case of mass cultures of unknown origin, but without success in the case of cultures made from single individuals. This was regarded as strong confirmation of the pure line principle until Calkins and Gregory, repeating the experiment on exconjugants, were unable to support it. Then Jennings, selecting a new species of Protozoa, more favorable for precise quantitative observation, also obtained a different result. He now found that among the observed fluctuations in size, those of a genetic character were included, so that by repeated selection races could be produced which were progressivley larger or smaller, rougher or smoother. This is fully in harmony with the observations of Stout who found that variations in Coleus arising in asexual propagation were capable of further propagation. It also harmonizes with the observation of Shamel as regards the occurrence in citrous fruits of bud variations which are important enough to warrant propagation in economic work; and further, with Winkler's clear demonstration of the occurrence in the tomato and the night-shade of *gigas* like mutations, arising first in single somatic cells, which asexually propagated produce entire plants of a new type which then are self-perpetuating by seed. We also have the observations of East that in the asexual propagation of the potato occasional bud variations may occur which are similar in nature to unit-character variations in reproduction by seed. It is accordingly clear that the pure-line principle does not apply without exception to asexually reproducing organisms any more than it does to self-fertilizing ones. It is true, however, that genetic variations are much less common among such organisms than among those produced by cross-fertilization. Herein lies the justification of present agricultural practice in the breeding of self-fertilized cereals, and of horticultural practice in the propagation by grafts, runners, layers, etc., of superior individual plants.

4. Attempts to extend the pure line principle to organisms which are not self-fertilizing (and this includes all the domestic animals and many cultivated plants) have met with small success. Morgan indeed assumes that it applies to his races of Drosophila up to a certain point, the point at which mutation begins, but the mutations which he recognizes are so numerous, so minute in many cases, and so fluctuating in others, that it becomes a question whether his "mutations" are not just ordinary heritable variations. Morgan would undoubtedly admit this since he claims that *all* heritable variations arise in mutations, but this is simply juggling with names, giving a new meaning to the word mutation in order to justify a sweeping generalization otherwise untenable.

The test of a pure line is its freedom from any genetic variation, so that selection cannot modify the racial mean as regards any character. As soon as any race of animals or plants changes in response to selection, it must be forthwith excluded from the category of pure lines. The consequence is that no case of a pure line among animals has yet been demonstrated. Nevertheless the "*principle* of the pure line" is in some way or other supposed by the followers of Johannsen to confer on even the higher animals a limited liability to modification in consequence of selection.

Thus Pearl having been entrusted in 1908 with a selection experiment for increase of egg production in Plymouth Rock fowls, an experiment which had already been in progress for nine years, decided after a study of the records kept by his predecessor that no improvement whatever had up to that time been made and further that none probably could be made since individual wild birds probably lay, under favorable conditions, as many eggs as their best tame relatives. This reasoning was strictly in accordance with the "pure line principle" and was in fact based on it.

Later by changing somewhat the basis of selection, so as to rank his animals on the basis of their progenies' performance as well as their own, Pearl found that he could considerably increase the flock average. Yet he still maintains that he has only *more* good birds not *better* ones, than when the experiment began, and in loyalty to the pure line principle he has no expectation of obtaining better ones in the future, since he already has and has had all along the *ne plus ultra* sort. One less devoted than Pearl to a generalization of the pure line doctrine would continue hopefully the effort to produce a *better* fowl as well as to produce more good ones. For the function of egg-production admittedly depends upon many physiological factors (as well as several external ones). These physiological factors must many of them be independently variable and to some extent independently heritable. Variation in one or more of these factors (by mutation or otherwise) would undoubtedly influence the total productiveness, and the probability of the occurrence of a mutation would increase with the number of factors involved. So that even one formally committed to the pure line doctrine, but admitting as Johannsen does that mutations do occasionally occur in pure lines, might hopefully continue to look for improvement in the standard of egg-production. No other method of detecting and utilizing a favorable variation, when it does occur, can be suggested than the very method of methodical and persistent selection against which the pure line advocates direct such vigorous attacks.

Morgan is a formal adherent of the pure line doctrine, but pragmatically a selectionist for he admits the great progress made in the improvement of domestic animals and plants by selection, and even that his own mutants of Drosophila fluctuate and yield modified forms in response to methodical selection, as for example the bar-eyed mutant, subjected with success to plus and minus selection by Zeleny. But he attempts to explain these results in harmony with the pure line principle by assuming that, whenever a modification is observed in any character, this is due to a mutation, and if a graded series of modifications is obtained, as in the plus and minus selected bar-eyed Drosophila, this is due to a multiplicity of mutating factors whose action on the chief factor concerned is purely incidental. On this view, however, the attainment of a completely homozygous condition on the part of all factors (if all are indeed Mendelian) would put an end to genetic variability, and selection would then cease to produce effects. Such a completely stable condition has, however, rarely been demonstrated. One case is reported by MacDowell, that of a race of Drosophila with an extra number of thoracic bristles. The average number of bristles was increased by selection for six generations but then showed no further increase and could not subsequently be changed either upward or downward by further selection. The race had apparently become a "pure line' for bristle number.

BIBLIOGRAPHY

CASTLE, W. E., 1916. Genetics and Eugenics. Harvard Univ. Press.

HOSHINO, Y., 1915. On the inheritance of the flowering time in peas and rice. Journ. Col. Agr. Tohoku Imp. Univ., vol. 6.

JOHANNSEN, W., 1909. Elemente der exakten Erblichkeitslehre. Jena.

MACDOWELL, E. C., 1915. Bristle inheritance in Drosophila. Journ. Exp. Zool., Vol. 15.

MORGAN, T. H., 1916. A critique of the theory of evolution. Princeton Univ. Press.

PEARL, R., 1912. The mode of inheritance of fecundity in the domestic fowl. Journ. Exp. Zool., Vol. 13.

PEARL, R., 1916. Fecundity in the domestic fowl and the selection problem. Amer. Ass. Nat., Vol. 50.

SCOTT, W. P., 1917. The theory of evolution. New York.

SMITH, L. H., 1912. Altering the composition of Indian corn by seed selection. Journ. Indust. Eng. Chem., Vol. 4.

DEVRIES, H., 1900-1903. Die Mutationstheorie. Leipsig.

WRIGHT, S., 1916. Studies of inheritance in guinea-pigs and rats. Carnegie Inst. Wash., Pub. 241.

[*To be continued.*]

Maori Burial Chests

THE fine series of Maori burial-chests in the Auckland Museum, with a few isolated specimens in other collections, are described in *Man* for July by Dr. W. H. R. Rivers and Mr. H. D. Skinner. The chests were used in secondary burial, the bodies being first placed in trees and the desiccated bones collected for re-internment. The custom of placing the dead or their bones in caves is widely spread in Oceania, but neither elsewhere in New Zealand nor in any other part of the Polynesia do we know of such chests. Receptacles, often in human form, are, however, used in Melanesia, notably in the Solomon Islands, to preserve the skull or skeleton. In the case of the New Zealand chests, similarly with Melanesian culture comes out in the nature of the chests themselves. In many respects in which the carving departs from the usual characteristics of Maori art it approaches that of Melanesia; and it is noteworthy that the part of the northern island of New Zealand where these chests have been found is characterized by the prominence of negroid or Melanesian character in the physical features of the inhabitants.—*Nature.*

Fruiting branch of the Chinese Jujube (*Ziziphus sativa*)

The Chinese large-fruited jujube constitutes a new fruit tree for America. It is adapted to the hottest regions of the Southwest, where it fruits abundantly. The fruits shrivel on the tree and can be gathered and kept in a dry state, to be processed with sugar later or used like raisins in puddings. The processed jujube is not inferior to the Persian date in flavor. This is the Mu shing hong variety (S. P. I. No. 22684).

The dasheen corms and their tubers

These are the product of a single hill of dasheens. The tubers are easily broken off of the corms and can then be cooked and treated just as potatoes are. They contain more protein and starch per pound than the potato, and consequently require more butter or gravy. They have a delicious nutty flavor.

The Palate of Civilized Man*

And Its Influence on Agriculture

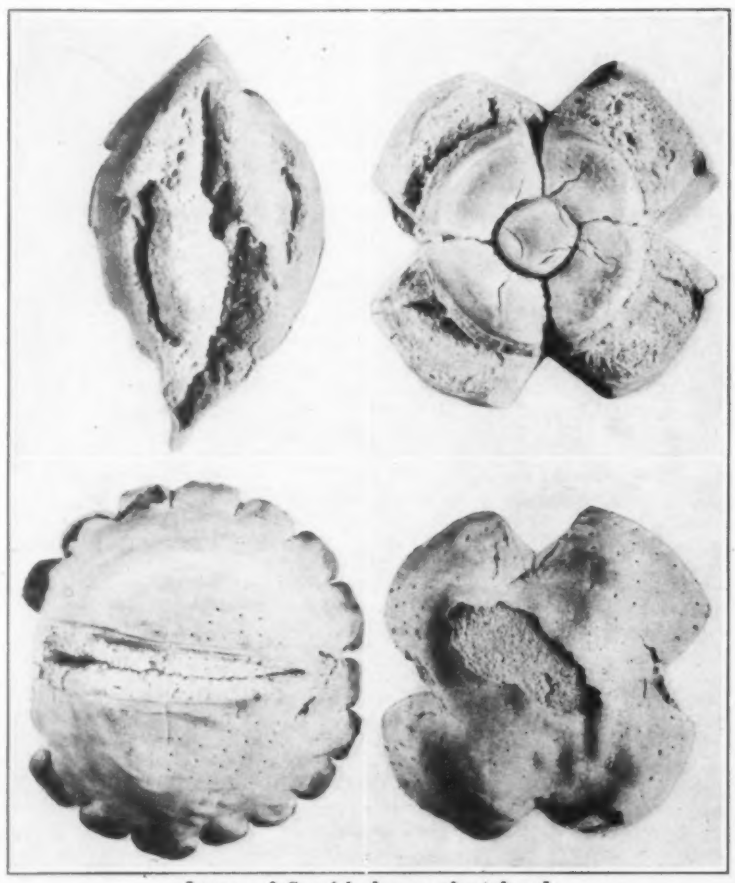
By David Fairchild, Sc.D., Agricultural Explorer in Charge, Office of Foreign Seed and Plant Introduction, U. S. Department of Agriculture

THE expression, "I do not like it," is the stone wall which blocks or hinders every attempt to introduce a new food. The purpose of the discussion this evening is to analyze the situation created by the vagaries of taste in foods and ascertain if these vagaries are not responsible for a larger part in agriculture than is commonly supposed—a controlling factor, even, in the cultivation of vast areas of land. My position in the Department of Agriculture, that of investigating the food plants of the world, to find out which could be introduced and grown in America, has perhaps permitted me to gain a bird's-eye view of the situation and warrants my making certain generalizations which grow out of twenty years of foreign and domestic correspondence and travel.

It seems to me that the present era is one of tremendous change and immense possibilities in these matters of food, and that the time is at hand when full discussion of taste in foods is opportune. The war is rapidly changing the trade routes of the world, and the Oriental tropics are brought closer to us than ever before by the lines of direct steamers through the Panama Canal. New York is now in direct touch with Java and Singapore, and a new direct line to Chile and Peru has just been opened. Sanitation, the discovery of the yellow fever mosquito, the advent of good roads and automobiles, have made farm life in the tropics a very different thing from what it was a generation ago.

We have the spectacle of hundreds of millions of people studying as they never did before the food supply of the whole world with reference to their particular contribution to it as a world-problem, not, as in former years, largely as a local question. One can hear in one's imagination the food talk of the Malay rice growers as they wade knee deep in the mud of the paddy fields of the Philippines. The llama drivers on the Cordilleras of the Andes, the *beche de mer* fishers off Thursday Island, the vanilla vine growers in the Seychelles, the banana plantation darkies in Jamaica, the Chinese tea pickers on the river of the nine windings, the Labrador fishermen, the New Zealand sheep rangers, the Liberian coast boys in their oil palm forests, and the Fijian coconut growers in their atolls in the Pacific—all are more or less affected by the great war and its effect upon the price of food.

Could a Southern planter or a Western farmer have imagined that the Belgians would refuse to eat his corn or that the British would even under the pressure of war prices buy corn-meal with great reluctance, and the reason be that "corn-meal is chicken food"? The soldiers' likes and dislikes in food have no doubt restricted and hampered the prosecution of the war. Blackberry jam formed an integral part of the ration of our miniature standing army, but it is hardly to be expected that it will be available for the million men soon to be in the field. Now, while the events and facts are fresh in every one's mind, it may be well to consider whether it may not be easier to change our minds than to change our agriculture.



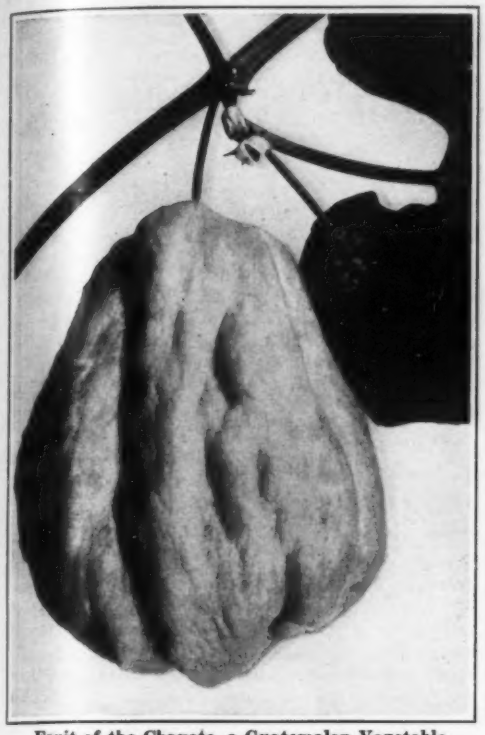
Loaves of Spanish durum wheat bread

In southern Spain the wheat bread is very different from ours. It is hard and yellowish and has a substance to it which ours does not have—yet the average American would not like it any better than the Spanish peasant likes our soft, spongy bread, even though it is quite as nutritious. It is made of a different species of wheat from that which we grew previous to 1898—the durum or macaroni wheat.

Consider the corn situation today and its bearing upon the gigantic problem before us of feeding starving Europe. When I first heard that the Belgians refused to eat corn, and that the Irish and English would eat anything else before they would touch it, my first impulse was to insist that they ought to be made to eat it. Edward Eyre Hunt, the author of "War Bread," explained and made it entirely clear to me that a shocked and outraged people, wrought up and nervous to a high degree as a result of the treatment they have received, is in no mental attitude to learn to like a new food. The task of education would have been too long and more expensive than the shifting of our own ménu at home, and in the meantime would have cost many thousands of lives. Resort was made to the use of different names for corn and concealment of it in war bread with three parts of white flour. Sir Horace Plunkett informed me that unfortunately his people had grown up to look upon corn as hog and chicken food, and that this prejudice was extremely difficult to overcome, but that high prices would in time force them to eat it. One of the British commissioners to this country remarked, last spring, to one of our Southern ladies, "Madam, I wish you could send us a hundred darky cooks to teach our people how to cook corn."

Not to like a food which has been the staple of peoples for thousands of years and today is produced by the thousand million bushels and feeds hundreds of millions of people seems to us who like it a strange, incomprehensible spectacle. Yet it is no stranger than that of the American people and their indifference to that other great cereal, rice, which is produced

*Presented at a meeting of the Section of Physics and Chemistry of the Franklin Institute, and republished from the Journal of the Institute by permission. Copyright 1918, by The Franklin Institute.



Fruit of the Chayote, a Guatemalan Vegetable (*Chayota edulis*)

This fruit, though with no pronounced flavor, has a remarkable texture and can be used in a large variety of ways. It is more delicate than a squash or cucumber. It is a staple vegetable in those tropical countries where it is grown, and is now being cultivated in Louisiana and Florida.

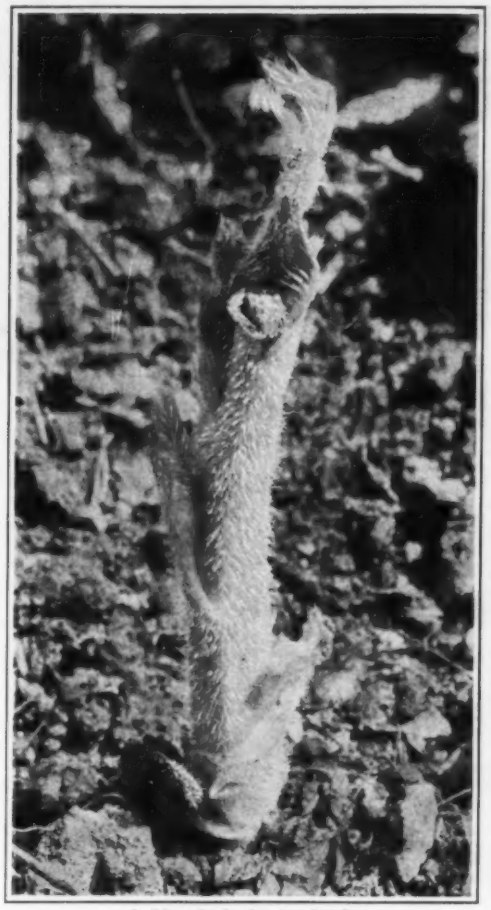
in larger amounts than any other cereal in the world and forms the staff of life of hundreds of millions of civilized peoples.

It is said that Europe is dependent upon the wheat loaf, and the bakeries of that country are ill suited to utilize corn. We are sometimes inclined to insist htat they should break away from the exclusive use of the wheat loaf and learn to make corn bread—yet we have not yet learned to cook rice properly, and complain of its insipid character, which must be an attitude hard for our Oriental neighbors to understand. This indifference toward rice, of which staple we even now consume only the insignificant quantity of seven pounds per capita, has led to the abandonment of the fertile rice fields of the Carolinas, and today efforts are being made to find some paying crop to take its place there, because our meagre demands have been met until very recently by the California and Texas rice areas recently developed.

I find that most people whom I meet have never stopped to think whether what they eat makes any difference to any one else. They drink their cup of coffee without seeing the vast red clay hills of Brazil covered with square miles of coffee trees loaded with red berries. They do not stop to realize that their preference for coffee instead of for cocoa or tea means that their money is contributing to the great civilization of southern Brazil instead of to the tropical cacao plantation life of Venezuela or Trinidad or the beautiful hillside farm life of the tea plantations of the Orient. Whether they drink Oolong or green or black tea seems a very small difference to them, but in the aggregate it means the success or failure of vast plantations with thousands of tea pickers in China, Japan, or Ceylon.

Can the fact be established that, in the past, fashion in foods, a like for a food or a positive dislike, or a mere indifference toward it has brought about the cultivation of the plant, checked or stopped its cultivation, or accelerated its widespread cultivation? If it can, there will be no longer doubt that the factor is important, and the question of its careful scientific investigation is one worthy of serious consideration by the scientific bureaus and laboratories of the country and our great educational institutions as well.

The origin of many cultivated plants dates back beyond the dawn of history, and many of them have become so almost universally grown that no traditions even are left to mark the struggle they had to gain popular favor. Others, again, are so new that they are at the present time fighting for a place on the ménu.



A blanched shoot of udo

Unlike the asparagus or celery, the blanched shoot of udo has no objectionable fibres in it. It is crisp clear down to the ground and has a characteristic flavor the like for which, like for almost all flavors worth while, has to be acquired.

A hill of blanched udo (*Aralia cordata*)

Every spring, before the hill of udo starts into growth, it is mounded over with light soil to a height of a foot or two, or a drain tile closed with cement at one end may be substituted. Under this soil or in the darkness of the closed tile the tender shoots grow up perfectly white. They should not be allowed to become green, as this gives them a strong flavor. They are tender from top to bottom and absolutely stringless.

The wheat plant and the loaf of bread made from its kernels are universally liked. There is no race of people which does not like it. Yet it is a fact that the delicious hard bread of Spain and Russia, made from the durum wheat, a distinct species from our wheat, is not popular today in this country, and macaroni, the most popular form in which wheat is used in Italy, has, until recently, been little appreciated in America. These two facts hindered the development of the durum wheats when they were first introduced into this country in the nineties. If it had not been possible to export wheat to Italy for macaroni making, there is serious doubt whether we should now have had the vast fields of it in Kansas, Minnesota, and the Dakotas. Millers had to remake their mills in order to grind the harder kernels, and bakers had to learn to mix it with softer wheats.

The oat is cultivated successfully in Hokkaido, the north island of Japan, but not for human food. It is used for the purpose of feeding to cattle in that island, and is imported in the south islands for the use of military horses, whereas we devote over thirty million acres to its culture. Oatmeal is a staple breakfast dish in millions of American homes.

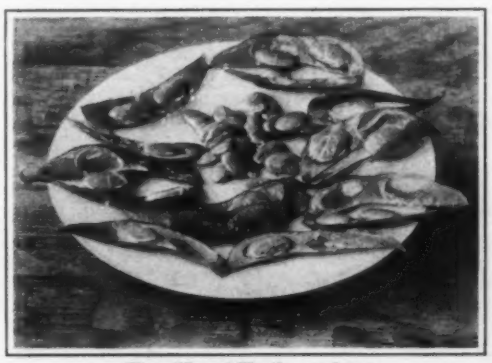
Buckwheat griddle cakes form the great breakfast dish in parts of New York and Pennsylvania, and are indispensable now to every city restaurant. To supply this fashion, which just after the Civil War was apparently at its height, we planted a million and a quarter acres of buckwheat. Today this has dwindled to three-quarters of a million. The Japanese, on their crowded areas, grew, in 1906, nearly 400,000 acres of buckwheat, yet I doubt if any Japanese who has not been in America knows the good qualities of buckwheat griddle cakes, and I am sure no New York or Pennsylvania farmer has ever tasted the buckwheat macaroni, which is the way in which the Japanese eat buckwheat. These two fashions have no relation whatever to each other, and yet each is largely responsible for the areas now under buckwheat cultivation in these two countries. They are both fashions that might die out and force buckwheat out of cultivation.

Examples could be multiplied almost indefinitely to show that just as what we like determines what we grow individually, so it does collectively.

The European grape was unsuccessful in eastern America and equally so in Japan. We originated the American grape varieties from our wild species and fortunately learned to be fond of their musky flavor before California began growing the European grape. This fondness for the Concord and Niagara and other American sorts has built up the Hammondsport grape

A field of dasheens in Florida (*Colocasia esculenta*)

The dasheen plant looks like the "elephant ear" of our gardens. It grows on soil which is too moist for the potato, and its tubers mature in November in the South, when potatoes are being shipped in from the North. When this vegetable becomes widely known, hundreds of thousands of acres will probably be planted to it.



The "dove-killer" soy bean

Some kinds of soy beans, such as the "Dove-killer," are delicious when gathered green, boiled in their pods in salted water, and then shelled. They are quite as attractive as lima beans and are even more delicate in flavor.

industry along the lakes of western New York. Europeans, although they use the root of our American grape because it is resistant to the *Phylloxera* disease of their vine, scorn to eat the fruit, and there is no culture of American grapes in Europe, even though they are more resistant to disease.

The Honey Dew melon came in a few years ago and is now a rival of the grape-fruit on our tables, and grape-fruit growers fear it. There was a time when the orange growers of Riverside would have been glad if Easterners ate only navel oranges. They were not vitally interested in the exploitation of any other variety or any other fruit crop. The present production of navel oranges in California approximates 27,000 carloads a year, or about two-thirds of the total orange shipments of the state. Yet one of the principal growers of Riverside has just reported to me that the recent hot wave almost completely ruined the navel orange crop this year, and he wants to grow something else. The fixed fashion of eating oranges and grape-fruit makes people keep on buying them regardless of cost, though the freeze last year cut the Florida crop to a quarter of normal and the drouth cut the California navels out entirely.

How did seaweeds and candied grasshoppers come into use in Japan, and fried rhinoceros hide in Africa, and powdered deer horns in China, and pickled pigs' feet in Germany, and mouldy cheese with skippers in it in England, and snails and frogs' legs in France, and grasshoppers, fried and reduced to a meal, in Arabia, and snakes and lizards among the North American Indians, and the octopus among the Neapolitans, and the woodgrubs among the New Zealand Maoris, and larks' tongues and eels fed on the flesh of slaves in Rome, and caviar, the eggs of the Volga sturgeon, among the Russians, and rats and mice and dogs and cats by the Chinese, and human flesh by the Fiji Islanders? Is it reasonable to suppose that these customs were acquired in some mysterious evolutionary way? Is it not highly probable that these foods came into vogue just as we know coffee and tea and the potato and tobacco and chocolate have come to be fashionable today in European and American countries, through the encouragement given those who set the fashions of the day?

Imagine the return of Raleigh to Great Britain and the social prestige which he must have had as the great explorer of the New World! Is it any wonder that men and, later, women, too, have followed him in the smoking habit which he brought back with him? Consider the millions of acres devoted to tobacco today as a result of the smoking fashion.

The rise in favor of the potato is one of the most spectacular in the history of the introduction of new food plants. Sir Walter Raleigh is given credit for its introduction into Ireland. The friars of Spain took it to Italy. There are records of the governor of Mons having received it from the papal legate of Belgium. When we remember the rank of Raleigh and the standing of the Catholic Church, it is easy to understand how potato eating became fashionable in Ireland—came to be the great food crop of that island. It was, in my opinion, the fashion for it which started its cultivation.

Columbus, on his return to Spain, presented a sweet potato to Queen Isabella, and today it is an important root crop in Spain and one of the principal food plants of the Madeira Islanders. The Portuguese seamen took it to Japan in those days when they were the great and powerful foreigners in the eyes of the Japanese. Today the sweet potato forms one of the principal crops grown on the upland fields of southwestern Japan, and is a most important food of the poorer classes.

The account given by the Japanese of the introduction of tea into Japan is a striking picture of the influence of a fashion upon a great plant industry. It was cultivated by the Chinese previous even to 2700 B. C., and had become fashionable there long before the Japanese introduced it into their ménu in 805 A. D. The Director of Agriculture of Japan, in his "Outlines of Agriculture," remarks that "at the beginning the Imperial court patronized and encouraged its cultivation, but later on the people at large began to appreciate it, so that it soon became an article of necessity for the people of all ranks and conditions in Japan. Therefore the cultivation of the tea plant has been extensively carried on in all quarters of the country, and the patronage given by the people in the upper class of society caused a striking improvement in the art of tea manufacture."

When we consider that the peach, the orange, the jujube, and at least one type of cherry and edible hawthorn originated in China, it is difficult to understand why fruits have not become more popular in Japan. The Director of Agriculture on this point is clear, for he says: "The Japanese have no custom of eating fruits as dessert, so that the demand for fruits was comparatively limited; . . . but with the frequency of communications with European countries changes have been wrought in customs and usages of the people which have strikingly augmented the demand for fruits."

Compare this statement with the last report of our own Secretary of Africulture: "It is a well-known fact that the consumption of fruits and vegetables has increased considerably in recent years, and that they constitute a larger and more important part of the permanent diet of the people."

I cannot avoid the feeling that these two officials, speaking of their own people as a whole, are a good deal like two mothers speaking of the peculiarities of their own families. "Well, my family won't eat that," is a familiar expression which one hears everywhere.

Did you ever watch an amœba, that primitive naked drop of protoplasm, send out one of its long feelers or pheudopodia toward a bit of copper or other substance, and, as soon as it comes within the radius of the chemical activity, recoil and return to its rounded shape? Taste in its primitive form is there, and on up through all animals, before the birth of the great organ of intelligence, and even after, it is a guiding factor of existence. If the squash bug would only change its taste and be satisfied with the pigweed, or the cabbage butterfly larva with the pokeweed, or the codling moth with our wild cherry instead of the apple, or the dog become a vegetarian and leave the sheep alone, or the horse, like the goat, live on bark and twigs, or the cow refuse to eat garlic, or hawks and foxes confine their taste to owls and muskrats instead of molesting our chickens, or even if grasshoppers were not such omnivorous feeders and ate only grass instead of every living green thing, the world we live in would be different. But we cannot change these inherited tastes, though they even are being modified somewhat to meet the new conditions arising on the planet. There are conclusive proofs, for example, that cats and rabbits wandering through our gardens taste of the new plants which are put there. The cats of Boston learned in less than two years from the time of its introduction into America that a wild vine from central China was good to eat, and ate it to the ground. The wild rabbits of western Canada singled out, nibbled, and killed a new species of ash from Turkestan the first year it was grown in a nursery on the prairie.

The appearance of intelligent man in the world, however, creates a new situation, and it is a question whether instinctive taste has not already disappeared in him, although perhaps some of the vagaries of taste in foods which are hard to explain do come down as instinctive traces from our ancestors.

Taste is the avenue of our contact with the world of chemical things. It is, after all, one of our five senses. Is it not worthy of all the study which can be given to it, and should not the education of the human palate become a matter of great importance and every effort be made to teach the value of a wide liking for everything that is good to eat? Let us not be misled by those who scoff at the problem. Scoffing is a trait unworthy of intelligent man. Think of the conservatories of music where the sense of hearing of thousands of our youth is trained, and the academies of art where the sense of sight is cultivated, and then compare these with the schools of Domestic Economy and see what a gulf there is between them. How far we must yet go to put the cultivation of the American palate where it really belongs!

The question, it seems to me, may with perfect propriety be asked in regard to our children, Are they not already acquiring incurable habits in foods? How many housewives stop to realize how the taste for sugar has grown in this country, or that, whereas France must limit each citizen to twelve pounds per year, we are said to be eating in the neighborhood of ninety. There was a time in the Middle Ages—and that is, after all, not many generations ago—when the only sweet things man had were honey, raisins, and such things as sweet fruits. Sugars were unknown and probably not liked by hosts of our ancestors—there are some today who do not care for sweets; but the sugar habit, like the tobacco habit or the chewing-gum habit or the alcohol habit, is going to bring about acute suffering in those who must give it up or curtail it, just as the bread habit and the meat habit are hard to change.

We have a curious spectacle in our common schools—thousands of little children poring over books on the volcanoes of the world which they will never see, the North Pole, which they can never expect to visit, and, when the noon hour comes, satisfying their hunger from their dinner pails with no word from the teacher regarding perhaps the most acute sense they have—the sense of taste.

I left school and college with about as untrained a palate as I had when I started in, and it took the knocks of travel to demonstrate to me the desirability, the necessity at times, of learning to like everything which is fit to eat.

The researches of modern chemistry have revealed startling things with regard to the requirements of our bodies—things which cannot fail to make one feel that discoveries of gigantic importance may at any time be made. To learn that rats or pigs will starve to death on an exclusive diet of Indian corn; that the rice we have all been eating will, if taken alone, produce the starvation disease known as beri beri; that a few cubic centimetres of the white of egg, if injected into the blood, so sensitizes the protoplasm of our bodies that a second dose will kill us almost as quickly as a dose of snake venom, are facts which make us wonder what discoveries we are approaching.

The consideration of food as fuel was a great step in advance in the food question, but the discovery of McCollum, that certain substances contained in butter fat and the green leaves of plants are just as essential for a complete food as the proteins, fats, carbohydrates, and mineral constituents contained in grains, has opened a new door of possibility. The machinery for determining the comparative protoplasm building and conserving value of foods is rapidly being created, and it is curious to reflect that the despised rat is being made one of the chief tools by means of which the food chemist is working them out. The human calorimeter, which amused the public at first, has come into prominence as one of the great tools of this generation. We are in a position such as we have never occupied before to test the value of the food plants of the world.

All these converging changes, it seems to me, indicate the present as a remarkable opportunity in which to consider whether the stone wall of taste is really a stone wall, or whether it is something which the reason of man can tear down—whether, in other words, the time has not arrived when we should cease insisting that our likes and dislikes in foods are nobody's business anyhow, and begin to realize in how far this caprice of fashion will hinder the development of the agriculture of the future.

"*De gustibus non disputandum*" is an expression which was originated by the scholastics of the Middle Ages and has, curiously enough, blocked for centuries the discussion of one of the most important subjects connected with the development of the human race.

The fact that plants can be found which are suited to different soils and climates, easier than the soils and climates can be changed, has been conclusively demonstrated. The date palm is perfectly at home in the Imperial Valley where the apple is a dead failure. The dasheen is a success on soils too wet for the potato. The kafir sorghums live and bear heavily on lands too dry for corn. Wheat cannot be grown everywhere, potatoes are a success only in certain regions on certain soils, and there are enough types of soil and climate to make places for more crops than most people know exist in the whole world.

The spread of plant diseases and the cost of their control is another factor forcing man to change his crops. Already in certain plant industries they are taking all the profits out of the cultivation of those plants. As the plantations of one crop grow in size and are owned by larger numbers of individuals, these costs of control often increase, and our farmers should be able to shift to other crops less liable to disease.

The pear blight has wiped out great orchard areas in this country, and other crops have taken their place; the watermelon disease has made watermelon growing unprofitable in certain sections; the glume rust of wheat threatens serious injury to the wheat area of the Northwest; the nematodes of Southern soils make fig growing in many places there impossible; the new peach twig borer may be the last straw that will discourage peach growing wherever it spreads; the American chestnut has already practically gone, and we will be dependent probably upon some immune hybrid between the Japanese chestnut and the chinquapin for our Thanksgiving chestnuts.

Armsby has emphasized the limitations of the hog and the steer as producers of necessary food material when fed on human food grains. Lusk points out the fact that indulgence in meat is due primarily to desire for strong flavor, and these facts may make meat too expensive for some of us and drive us to the use of soy sauce, the great flavoring extract of the Orientals. These peoples have not acquired the expensive taste for beef; in the place of beef gravies they consume over ten quarts per adult per year of a sauce made from soy beans and wheat—a teaspoonful or so at a meal. That changes in our ménus are coming there can be no doubt. The above causes are at work, and some of the changes that we may have to adjust ourselves to in the next generation may be surprising.

Conservatism in taste has no doubt been a great stabilizer, but has it not increased the chances for specu-

lation and made "corners" possible? It has enabled the farmer to know with some degree of certainty when he plants his orchard that there will be a demand for the product of his orchard ten years hence. Doubt as to the existence of this demand will prevent him from planting the orchard. It has simplified, no doubt, some of the marketing problems which depend upon advertising. The change of fashions in foods adds one more element to the gamble of agriculture. A broad universal diet, however, should give room for the development of all the good plant and animal foods of the world. Our American children of the next generation should be more untrammelled than we have been in their diet, and able at any time to shift from one food product to another as the price or shortage dictates. They should have a mobility of action which will enable them to go anywhere and eat anything fit to eat, and test out and eliminate or keep, as the case may be, any new foods which the investigations and experiments of plant introduction and plant breeding and the growing genius of food chemistry will surely bring into existence.

But throughout all this discussion I cannot help wishing that the great man Franklin, the greatest in some ways that America has produced, could look up from his bowl of porridge, which he says in his autobiography formed for years his daily breakfast, and tell us how this great country can be utilized agriculturally, if everybody should insist on a breakfast of oatmeal porridge and milk and nothing more.

Undamped Currents in "Supper-Conductors"

An interesting account is given in the "Sweizerische Elektrotechnische Zeitschrift" of some remarkable experiments conducted by Prof. H. Kammerleigh Onnes, at the University of Leiden. In ordinary circumstances, as is well known, a strictly undamped electrical current cannot exist. The oscillating currents which may be set up in a resonant circuit die away in a short interval of time, unless a continuous supply of energy is available. Such circuits always contain appreciable resistance, so that the damping factor is never nil.

Prof. Kammerleigh Onnes, however, has contrived to produce what he terms a "super-conductor"—*i. e.*, a conductor without appreciable resistance—by the application of extremely low temperatures. Granted the possibility of such a conductor, one must also assume the possibility of maintaining a continuous current without an appreciable E.M.F. From purely theoretical considerations it has been deduced that the specific resistance of mercury, at 4.25° Abs. would still be measurable, but at 2° Abs. would become negligible. Experiment, however, elicited the interesting result that when the temperature was reduced to a certain point—viz., 4.19° Abs.—the resistance fell suddenly to an almost immeasurable value. This marks the transition from conditions of normal conductivity to "super-conductivity." Once the temperature fell below this critical point it was found possible to pass a current at a density of 1,000 amperes per square millimetre through a conductor 1 metre long without any appreciable difference of potential between the ends.

Super-conductivity, however, is not merely a matter of temperature, but also involves a certain minimum critical current density. If this critical current density is exceeded the condition of appreciable conductivity suddenly appears, and the production of appreciable heat through the passage of the current increases the resistance still further so that a sudden rise in the P.D. between the ends of the conductor, and a corresponding diminution of the current takes place. Slightly below the critical temperature the permissible current density is very low, but by cooling the metal further the current density may be allowed to assume a considerable value.

Such a super-conducting closed circuit affords an opportunity of proving by experiment the qualities attributed in electrical theory to a resistance-free circuit. As mercury presents drawbacks it was found preferable to work with other metals—for example, tin—for which the critical temperature is 3.8° Abs., or lead, for which the critical temperature is 6° Abs. Of special interest among the phenomena rendered possible by such circuits is the possibility of producing quite easily magnetic fields of enormous strength. Hitherto, the limitations of heating have prevented a value exceeding about 60,000 gauss being attained. Prof. Onnes, using 1,000 turns of lead wire 0.1 mm. thick, and an iron-free path 1 cm. diameter and of similar length, attained an induction of 100,000 gauss in air, with the expenditure of only 1 joule of electrical energy. Here again an interesting new phenomenon came to light, namely, that there is a certain critical field strength (about 1 kilo-gauss for lead at 1.8 Abs.) beyond which the resistance suddenly rises, and heat is developed. The further one proceeds below the critical temperature the higher is the critical strength of field.

The ends of the lead spiral were next welded in the oxy-hydrogen blow-pipe, whereby the necessary junction of super-conductivity could be attained. In this way a circuit having only the so-called "microresidual" resistance was produced, and the spiral was actually found to have a resistance of only one twenty-billionth of an ohm, as compared with 736 ohms at normal room-temperature. In this circuit it was possible to excite a current of 0.6 ampere, which lasted for several days. The lead spiral in the "kryo-state" (from Greek kryos, cold) was enclosed in a field of 200 gauss, and cooled to 1.8° Abs. By the rapid removal of the field a current was generated, the existence of which was proved by the fact that turning the spiral about a vertical axis deflected a compass-needle in the vicinity. Repetition of the experiment with a substitution coil (at ordinary temperature) carrying a known current showed the existence of a current of the order of 0.4-0.6 ampere flowing in the lead spiral. It was further shown that the diminution in the current resulting from the remaining micro-resistance only amounted to 1 per cent. per hour, so that the current would flow in appreciable strength for about four days. As soon as the spiral was removed from the liquid helium and its temperature allowed to rise, the current vanished almost instantaneously.

It was next of interest to ascertain how the super-conductor would behave when it was attempted to generate an alternating E.M.F. in it. For this purpose a powerful magnetic field (but still within the critical value) was brought close to the lead spiral and then withdrawn again. As was to be expected, the two inductions counteracted one another, only a very minute current remaining. Next, the experiment was repeated with a more powerful field, corresponding to about twice the critical current. The approach of the field naturally induced an initial current, which rapidly fell to the critical value. The withdrawal of the field, which likewise would induce a current of twice the critical value, but in the opposite direction, resulted in the elimination of the existing current and the final exciting of a current in the opposite direction and of about the critical value. The repetition of this experiment with very powerful fields led to similar results.

All these phenomena are completely in accord with the hypothetical qualities assigned to a super-conductor. The conditions were verified in yet another way by connecting a ballistic galvanometer to the ends of the lead spiral. The approach of a field as before excited a steady current in the spiral, which revealed itself by the deflection of the adjacent compass-needle. The junction of the two ends of the spiral was suddenly broken, and this resulted in a momentary deflection on the galvonometer and the return of the compass-needle to its original position. The interruption of the short-circuit between the galvanometer connections at once produced a condition of ordinary conductivity and the annihilation of the current; the self-induced current would only persist for about one hundred-thousandth of a second after the cessation of the inducing E.M.F. All these phenomena recall Maxwell's theory of a frictionless mechanism which in these days can be extended to the electron theory. When an electric current consists simply of the flow of electrons between the molecules of a conductor, we have undoubtedly to do with a frictionless current and a condition of super-conductivity. The electrons once set in motion travel in a closed circuit without any E.M.F. just as in the Maxwell theory of matter rotating rings are formed, the motion of which continues without intermission; but if the least resistance is introduced this form of perpetual motion mechanism is brought more or less quickly to a standstill.—*The Electrician.*

Pond Collecting: A Tip

A few weeks ago I was thinking of spending a few days at Dorking, a neighborhood rich in streams and brooks, and, of course, wished to utilize opportunities of collecting specimens of the abounding aquatic flora. Being desirous of keeping my impedimenta as light as possible for so short a stay, I set to work to reduce my collecting outfit to the lightest possible extent, and hit upon the following plan to avoid the weight of bottles and water. I obtained a piece of very fine waterproof linen, and made a small bag about 10 by 12 inches, joining it up with Dunlop indiarubber solution; when thoroughly dry, filled it with water and found to my great content it was absolutely watertight. This solved my difficulty; all I required in my satchel was the bag and my drag. On my last morning, went down to a stream I had carefully prospected, and dragged out a lot of weed, placed it in the w. p. bag just as it came out, without adding any water beyond what drained off the weeds. On my arrival home in the evening, turned the stuff out into a large bowl of water, next morning sorted it out and filled a number of bottles to be kept under observation until, in course of time, various interesting objects might develop.

This plan, simple and easy, will, I anticipate, save me a lot of trouble in my future excurions of a similar character, and I think it may commend itself to others who probably have felt the inconvenience of carrying home their spoils in bottles of water for perhaps considerable distances. If it turns out that my plan has been carried out by others, well, all I can say is, I wish I had known of it long ago.—*The English Mechanic.*

Warping of Steel Through Repeated Quenching

Last year, when discussing Dr. Carpenter's paper before the Iron and Steel Institute on "The Growth of Cast Iron after Repeated Heatings," Dr. Stead remarked that repeated quenchings tended to contract length and extend to breadth, so there was a possibility of converting a long bar of soft steel into globular form by repeated heating and quenching. In his paper before the Iron and Steel Institute, Mr. J. Whiteley confirmed this. He said that in a Stockton workshop a small tank of water was heated by immersing a red hot cylindrical piece of soft steel about 3.5 inches in diameter. The analysis gave: carbon, 0.05 per cent; silicon, 0.01 per cent; phosphorus, 0.8 per cent; sulphur, 0.05 per cent; manganese, 0 45 per cent. "Measurements taken indicated that after 800 quenchings, the cylinder had contracted in length about 0.75 inches and had also increased in width by a corresponding amount. Each quenching must, therefore, have caused a maximum displacement of material in a lateral direction of about $\frac{1}{1000}$ of an inch. In this connection it may be remarked that the internal forces due to the tension of the skin may be resolved into two components, one acting parallel with the vertical axis, and so tending to shorten the cylinder, the other acting at right angles to the axis, and so tending to lengthen the cylinder. The direction and amount of movement in the piece which will take place during each quenching will depend upon the difference between the sum totals of the two components acting at various points in the material.—*The Practical Engineer.*

Causes and Prevention of Myopia

The Lancet publishes an interesting article on the "Cause and Prevention of Myopia," by Dr. F. W. Edridge Green. It is generally agreed that myopia is an acquired defect resulting from the elongation of the eyeball, but its causation has not yet been determined; the evidence for the assumption that near work produces near sight, being unsatisfactory. Dr. Edridge Green claims that the primary and essential cause is an obstruction of the outflow of the lymph which should empty itself from the lymph space between the retina and choroid into that of the optic nerve. The accumulation of fluid increases the intra-ocular tension and, distending the sclerotic (whose posterior part is weak), causes the eyeball to become elongated. The obstruction may be produced by severe muscular effort, *e. g.*, by lifting heavy weights, when a feeling of tension is always felt in the eyes, which appear, in extreme cases, to be starting from the head. This is more especially the cause of progressive myopia among warehouse boys, porters, and others whose work involves excessive effort, while with those engaged in sedentary occupations the form of exercise taken may be responsible, *e. g.*, wrestling, rowing, digging and also coughing. Thus when signs of commencing myopia appear anything likely to increase the intra-ocular tension should be avoided while, on the contrary, young hypermetropes should take as much exercise as possible. There is no need to avoid reading. No comments on the theory have yet appeared in print.

New Uses for Some Raw Products

The *Weltmarkt* directs attention to new uses of some raw products. In Holland a useful gum or paste is being made from garlic. The bulbs are pressed and the juice or fluid matter so obtained is thickened by inspissation. A good substitute for cork is obtained from certain fungi, which are dried and ground, mixed with cement, and consolidated by pressure. In Norway a process has been patented to enable carbide to be used for driving motors. In Denmark a company has been floated to make briquettes from heather. These have a higher heat value than peat. Experiments are being made to use chalk marl, especially that which comes from the Limburg mines as a manure.

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A battery of converters in which the copper matter is refined

Pouring blister copper into plate molds that move progressively under the spout

The Production of Copper

COPPER is one of the most useful of known metals, for, because of its special properties, it finds many applications in manufactures and the arts. On account of its ductility and strength, together with its resistance to the action of the atmosphere and many chemicals, and its high conductivity for heat, it is widely used for apparatus in chemical works; and in a pure state it is the best industrially available conductor for electricity, which makes it almost indispensable for many parts of electrical machinery and apparatus, as well as for transmission wires.

Alloying with other metals, in which it forms the principal constituent, opens up still a fresh field of usefulness, which has not yet by any means been exhausted. Thus we have brass of varying composition and qualities, while the list of bronzes, of which copper forms the basis, is very extensive and constantly growing. Bronze was in fact the first metallic compound known to man, and the time of its discovery is so far in the distant past that no one knows when it originated, nor where.

Without copper numerous technical enterprises could be conducted only with difficulty and in an inefficient manner. This was clearly shown during the war in the numerous make-shifts to which Germany was compelled to resort in many directions, for practically no copper ore exists in that country, and she had to eke out the supplies she had accumulated by scanty contri butions from Turkey and other neighboring region where the metal exists, but has not been developed. One of the pressing requirements of the war was for copper bands on the shells for her big guns, and it is well known how the Germans seized not only all the copper utensils to be found in their own country, but ransacked every inch of the invaded territory for similar articles, church bells, etc.

Copper ore is widely distributed throughout the world, but very unequally, and at present the United States is the principal producer. Occasionally copper is found in a metallic state, but this occurs in appreciable amounts only in the famous Lake Superior mines, and the chief source is in the form of sulphide ores. There are a number of processes for recovering the metal from the ores, and in a general way it may be said that the coarse ores are first smelted in a furnace similar to the blast furnaces used for reducing iron ore, while fine ores are first smelted in reverberatory furnaces, in which the ore is partially refined, and considerable of the impurities are drawn off as slag, while the remaining metal is known as matte. This matte then goes to the converters, which resemble those used in the Bessemer steel process, in which a large portion of the remaining impurities, consisting of sulphur, iron, and small amounts of zinc, arsenic and other metals, are separated out, and the resulting metal is sufficiently pure for most purposes.

For electrical work, however, a very pure metal is required, and the commercial metal above described still contains small quantities of a large number of other metals that reduce its conductivity. Among these adulterant metals are gold and silver, which often occur in sufficient quantities to pay for their extraction. For the production of pure copper for electrical purposes an electrolytic refining process is employed, in other words the pure metal is produced in an electroplating battery. In one form of this process plates of

16,000 tons of copper ready for shipment

commercial cast copper are suspended in a plating bath, and the first plate is connected with one pole of the source of electric current, while the other wire of the circuit is connected with the last plate, thus forming a *series* connection. In operation the electric current dissolves copper from the first plate and deposits it on the near side of the second plate; the other side of the second plate gives off metal to the near side of the third plate, and so on through the series of plates in the tank. When anode is nearly consumed it is mechanically separated from the pure copper deposited on its back. A scond, and better process is to prepare a set of pure copper cathodes plates, by electrically depositing copper, in a special bath, on greased lead plates, from which it is stripped by hand. These cathodes need only be very thin, and the refining battery is then made up of alternate cast anodes and these thin cathodes, which are connected in *multiple*. This latter process is the one most generally used, and works much faster than the previously described system. The silver, gold and other substances contained in the cast plates settles in the bottom of the plating battery as a slime, or is contained in the solution of the battery, and can be recovered from these sources by appropriate processes.

Breaking of Liquid Skins

WHEN a drop of some liquid is placed on a plane glass plate, and a ball put in the liquid and made to roll on the plate, the liquid will be squeezed out in front of the ball in the direction of the motion and obliquely to it, and will be drawn in in the corresponding direction in its rear. When the velocity of motion exceeds a certain small value, the liquid skin breaks in the rear of the point of contact. The phenomenon is watched with the aid of a glass lens (stead of a ball) and of the Newton rings, and when the breaking occurs, a bright curved line is seen which, on increasing the speed of motion, assumes the shape of a crescent or series of crescents, and of a broad bright band. This was observed by the late August Toepler who is known by other optical studies and in connection with air pumps and the Toepler-Holtz electric influence machine. In the *Annalen der Physik*, of June, 1918, pages 337 to 370, his son, Professor Max Toepler, of Dresden, describes measurements of the velocities and forces involved. He first tried to replace the rolling ball by the bob of a pendulum. As this would not answer he fixed two glass plates on the bed of a lathe, placed a plane-convex lens on each plate and mounted a frame of aluminum and wood on the lenses; the frame was rocked by a pendulum so that each lens tilted to and fro in the drop of liquid put on its plate. Many liquids were experimented with, pure water, mineral waters evolving gas, salt solutions, alcohols, amylacetate, etc. Toepler observed the following values of the critical velocity breaking the skin of the liquid: water, 1.1 cm. per second, sodium chloride solution 1.8, alcohol 0.4, chloroform 1.19, benzene 1.36, toluene 1.46, carbon bisulphide 2.59, glycerin 0.017 cm. per second. He also investigated the influence of gases and impurities in the liquid, of radius of curvature of the lens, load put on the lens, etc. It will be seen that the velocity was very small for viscous fluids like glycerin, and Toepler found that the product $vr.n$ is approximately of the constant value 0.00714; here v indicates the breaking velocity and n the coefficient of friction of the liquid in dyne-seconds per square cm. Some such relation must evidently prevail; but it does not appear that the method would be convenient for determining the internal friction of a liquid.—*Engineering*.

A floatation machine that concentrates fine crushed ore, eliminating most of the refuse

Copper plates being dumped from moving molds on a chain conveyor

The Constitution of the Earth's Interior*

THE problems of the interior of the earth are primarily of a physical character, and, in the final appeal, only to be decided by mathematical treatment; but this, in its turn, must be based on observation, and, therefore, it comes that this discussion is prefaced by a statement of the results which have been obtained by the sciences of observation. The preparation of this statement is simplified by the fact that the problems fall naturally into two tolerably distinct groups: (1) those relating to the outermost layer, amounting at most to 1 per cent. of the radius, and (2) those of the deeper portions, extending to the centre.

The latter may be taken first. Records of the transmission of mass waves set up in connection with earthquakes show two well-marked groups representing two forms of wave-motion, presumably the longitudinal and transverse, and a steady increase of the rate of transmission, with no very marked break in regularity, up to a distance of about 120° from the origin. Beyond that the first phase, of longitudinal waves, shows a decrease in velocity, and the second phase, of transverse waves, which, though so conspicuous at lesser distances, are no longer represented in their typical form, but are replaced by a record of different character, probably not due to any form of wave which has followed the direct path from the origin, and markedly delayed from the time at which they should have arrived had the same relative rate of propagation been maintained as at lesser distances. The depth reached by waves emerging at 120° from the origin is about half the radius from the centre of the earth, and the conclusion to be drawn is that down to that depth the material of which the earth is composed is sufficiently rigid against stresses of short duration, and sufficiently isotropic to permit the transmission of the two forms of elastic waves and to give rise to their separation by reason of the different rates of travel. Further, it seems that down to a depth of half the radius there is no marked change in the character of the material, but at greater depths there is a change in physical character to a material, or form of matter, which is no longer able to transmit the distortional waves, or, if capable, can only do so with a great diminution of intensity and at about half the rate in the lower layers of the outer shell; in other words, the material in the central nucleus has a very low degree or rigidity, even against stresses of only a few seconds' duration. The limit between the central nucleus and outer shell lies between the four-tenths and five-tenths of the radius, measured from the center of the earth; the transition between the two is apparently gradual, and not sufficiently abrupt to give rise to reflection of the waves at the junction of the two.

Turning to the outer layers, we have, next the surface, partly material which has been disintegrated by the processes of surface denudation, transported, deposited, and resoldified, and partly rock which has not undergone these processes, but is thoroughly cooled and solid in every sense of the word. These rocks have been subject to very considerable mass-movements and deformation, the displacements amounting in extreme cases to as much as ten miles in the vertical and one

A battery of ball-mills that pulverize the ore before it goes to the concentration machines

hundred miles in the horizontal direction. The ultimate cause of these movements is unknown; they can only be directly observed in the outermost skin, and are probably taken up in a different form in the deeper layers, but require that beneath the outer solid layer—which for convenience, and because some name is required, is commonly called the crust—there must be material which has some of the properties of a fluid, but not necessarily more than the power of change of form when exposed to stress of sufficient magnitude and duration. The thickness of the outer crust has been estimated by several distinct lines of deduction, all of which agree in giving a figure of about twenty-five miles, and this may be taken as indicating the order of its magnitude. The only means of arriving at any idea of the nature of the transition from the crust to the underlying material is in the reflection of earthquake waves; this is ordinarily treated as taking place at the surface of the earth, but there are grave difficulties in the way of accepting this interpretation. A more probable one is that reflection takes place at the under-surface of the crust, indicating a somewhat abrupt transition from the solid and rigid crust to the more yielding layer below. Whether this is a separate layer or merely the outermost part of the shell capable of transmitting both forms of elastic waves is still unknown.

The general result is that three distinct divisions can be recognised in the interior of the earth:—(1) The outer crust of solid matter possessing a high degree of rigidity, whether against permanent or temporary stress, of comparatively small thickness amounting to about ½ per cent., and not more than 1 per cent., of the radius; (2) a shell of material of thickness about one-half of the radius which has a high rigidity as against stress of the duration involved in the production of the tides, or of shorter duration, but, in the outer part at least, a comparatively low power of resistance to stress of secular duration; and (3) a central nucleus of material which has a very low degree of rigidity, even against stress of only a few seconds' duration. The transition from the first to the second of these three divisions is somewhat abrupt, sufficiently so to give rise to reflection; between the second and third the passage is more gradual, and lies at about four-tenths or five-tenths of the radius from the center of the earth. These three divisions may be further reduced to two—the outer layer, which in geology is known as the crust, not from any implication of the nature of the rest of the earth, but merely in recognition of a difference in character; and the central core, consisting of the rest of the earth.

*Synopsis of the opening of a discussion at a meeting of the British Association Geophysical Committee, by R. D. Oldham, F. R. S. From a report in *Nature*.

Anastigmatic Eyepieces

EYEPIECES in present employment suffer from nonfulfilment of the Petzval condition, having either a curved field or pronounced astigmatism. To produce an anastigmatic combination it is sufficient to employ a concave and a convex lens of approximately the same focal length. This combination is similar to that of the well-known Barlow lens. The novelty of the new eyepiece lies in the carefully computed almost achromatic negative lens, magnifying the primary image about four times, and a specially designed positive used in conjunction. By adjustment of the separation between the two elements variations of the magnifying power may be obtained.—*Note in Sci. Abstr. on a paper by A. E. Conrady, Roy. Astrom. Soc.*

A Wax Medium and Process for the Permanent Coloring of Photographs*

By A. Vernon Godbold

"If, in any work to be executed in azure and best sinopis, he shall be found by the dean and the jury to have cheated with the materials, the delinquent shall incur a penalty of 10 livres parisis."—Dalbon's Origines de la Peinture à l'huile.

Much time, thought, and search was given in the nineteenth century to discover the secret of the great old masters why their colors retained sweetness and purity of color, and what was their perfect technical method which preserved their work for nearly four centuries. When in olden times such a clause as the above was part of the artist's contract, and when they had to prepare and grind their own colors, therefore using them carefully and sparingly, their secret is obvious. The result was also to a great extent brought about by the severe regulations framed by associations, guilds, and bodies of master painters, and it would be a good thing if guilds were in existence today, because, with large firms and big banks amalgamating, it is not difficult to prophesy that they will have to be re-established in order that craftsmen and trade workers may live.

Artists have now a far better selection of permanent colors than the old masters, but they still have to find a perfect vehicle that is easy to work with, without chemical action upon colors, possessing protective qualities, and, above all, permanent. Painting struggles with difficulties; all sorts of agglutinants have been tried to help to produce opacity, transparence, dryness, and the appearance of moisture with contradictory obstacles. The importance of the vehicle is manifest in many ways; it means a different process, with its advantages and disadvantages, according to the agglutinant used, their proportions, their action on colored powders, and is the all-important question to those engaged in coloring photographs.

Wax, which seems to answer nearly all our exact requirements, is well known, but in little use, the reason being apparently that it requires special treatment to make it amenable to artistic use. In order to understand its virtues we must compare it with linseed oil and varnish, the two most important binding vehicles in use. The distinguished French painter and chemist Vibert did not believe in the use of linseed oil, but used a resin varnish reduced with benzine. Gersaint, who knew Watteau personally, deplores his abuse of oil, and adds: "It must be admitted that some of his pictures are perishing in consequence day by day; that they have changed color completely, or have become very dirty, and that nothing can be done to mend matters; but, on the other hand, those which are free from this defect are admirable, and will always hold their own in the finest collections." In "Picture Making" C. J. Holmes says: "The oils use in painting, however carefully they may be clarified and refined, tend with the lapse of years to rise to the surface of a painting and form a semi-resinous coating of brown or yellow, which certainly darkens their tone and destroys their freshness. The painter is thus compelled to get rid of every superfluous atom of oil in his picture if he wishes it to retain its pristine brightness." One can say, without exaggeration, that many pictures have been spoilt by a bad quality resinous varnish, badly applied. Varnish has destroyed hundreds of engravings, mezzotints, and the like, which it ought to have protected, instead of which it deteriorates to such an extent that it becomes darker than tar, proves worse than useless, and is responsible for 75 per cent. of the cracks, apart from some varieties being subject to bloom. You have to rely upon a firm's reputation, and if you should find a great change in the varnish after a year or so, the manufacturers kindly inform you they give no guarantee. Now, if we can make our own vehicle we shall be somewhat in the position of the old masters, knowing what we are using, and meeting the question of permanence more than half-way. Volumes have been written on the subject of oil and varnish, but enough is said here to prove that transparent oil is not permanent, especially on paper, which is the point that matters to photographic artists.

Virgin wax is free from the faults just mentioned, and is the material the ancients believed in, so much so that clothes were dipped in it to wrap round their dead. Ancient writers speak of the use of wax for painting, but not of their methods, so their technique is unknown to us. Excellent examples of the use of melted wax as a binding material for pigments may be seen in the National Gallery and at South Kensington. They are encaustic portraits, executed probaly 2,000 years ago, and were discovered by Mr. W. M. Flinders Petrie in the Hawara Cemetery, Fayum, Egypt. All great artists have been interested in the question, and yet very few experiments have been made as to the utilisation of exotic and vegetable waxes in the process of painting. The Hon. J. Collier, in his book, "The Art of Portrait Painting," writing of Sir Joshua Reynolds' technique, says: "Later he seems to have adopted Venice turpentine and wax almost exclusively as a medium for the heads, while the draperies were painted with wax without the turpentine, thus getting a richer impasto."

Raffaëlli, in 1903, created some sensation in art circles by inventing his "pencils of paint," after the manner of pastel, ready for use. His discovery is a derivation from encaustic, and the sticks seem to be composed of a similar mixture. His success would have been more lasting if he had introduced a cerate paste or medium.

The following wax medium was put forward the end of last year:

To make the medium:

White wax (bleached beeswax)	1 oz.
Carbon tetrachloride	1 oz.
Turpentine	1 oz.
Benzine (refined naphtha)	1 oz.
Ammonia .880	1 dr.

Melt the wax in a jar standing in a saucepan one-third full of water, and then add the carbon tetrachloride, remove from heat, and add, drop by drop, the ammonia, stirring all the while. When it has done frothing, add the 1 oz. turpentine, heat up again for a moment, remove from heat, and, when cooler, add the benzine and stir well for a minute or so.

For safety's sake, use a larger vessel than necessary to hold the quantity required—say, 1 lb. jar for 4 oz.

The object of the carbon tetrachloride was to make the mixture in the heat less likely to catch fire; also to assist a small quantity of ammonia to saponify the wax, because an excess of ammonia discolors the wax to a golden brown. Wax will not amalgamate with oil; the adhesion of the various coats of color is not perfect, but when saponified it is so. Carbonate of potash will saponify wax, with water to start the action, but water also makes this reagent faulty. Water evaporates out, leaving small pinholes in the film of varnish, and is therefore objectionable, and if carried over water-colors it is liable to disturb the painting.

An improved method of making the wax medium is:

White wax (Cera Alba)	¼ oz.
Spike oil of lavender	½ oz.
Hard primrose soap	1 dr.
Gum elemi	2 dr.
Turpentine	3½ oz.

Gum elemi is for hardening the mixture, and should be dissolved in ½ oz. turpentine and strained to get rid of the grit and dirt.

Place the soap on a plate and, with a table-knife, knead it with oil of lavender until you get a jelly, gradually adding about 1½ oz. of turpentine. Next melt the wax in a small jar, add 1 oz. turpentine; when cooler—say, 70° F.—add the gum elemi and the turpentine jelly, stirring well for a minute or so. Store in a glass jar with boxwood cork stopper as most convenient.

From the jar of medium take a small quantity and mix it with a little powder color, or oil color, to the required depth of tint with a palette knife on the palette (a china one is best). Then, with a soft piece of rag over the tip of the index finger, rub the tint over the enlargement or picture to be colored. If the tint is too dark, use more medium; if too light, add more color, spreading well over the part to be colored. It is important that the color, when laid on, should be of the right consistency—*i. e.*, it should have the right proportion of color, medium, and oil of turpentine. The smaller the surface to be painted the drier should be the paste, but too dry a color forms a granular appearance or layer on the photograph. Suppose you wish to color an admiral's coat, tint the medium with Antwerp blue, rub evenly all over, and then, with medium, or the rag moistened in turps, wipe off clean the buttons and gold braid parts and tint with chrome yellow or gold color to your liking. Similarly, the face, eyes, and lips are easily wiped clean for the final touches with brushes or stumps.

Before you begin, remove all black spots caused by pinholes in the copy negative and other dark markings likely to be detrimental in the usual way; next tint all the big masses first and smaller next, and then, with lead pencil, touch out white spots. Large spots need touching up with color and brush. For the eyes (small work, lines, and markings) use a brush of suitable size. If the photograph is a good one, the process is a simple matter, but if showing enlarged retouchings, etc., waterproof spotting is best, and should be done first.

The advantage of using powder color is that it dries more quickly; oil retards the drying. Palette and brushes are easily cleaned with turps, benzine, or petroleum spirit. Do not use more medium than is necessary to get the desired result. If the face is delicately modelled, use a transparent flesh color, and if the shadows are too dark use an opaque mixture. If powder colors are not to hand, take oil colors; if they are of poor quality or contain an excess of oil, spread on blotting paper or a slab of plaster of paris to absorb the oil, then transfer it to china palette. The deep shades of pastel, being nearly pure powder, can be made into a colored paste with the medium and used.

The process presents the following advantages:

1. It is easy to color large surfaces easily and uniformly.
2. The color can be entirely removed by turpentine without affecting the photograph if the coloring is not to your liking.
3. The colors dry fairly quickly, yet time is given for the passage in hand.
4. The medium will carry a tint over dry water-color without moving the underlay.
5. The texture of the photographic image is left unchanged.
6. It possesses the power of adhesion to the surface of photographic paper to a superior degree than water-color.
7. It has remarkable spreading qualities; is easy and pleasant to work with.
8. The paint is more pliable, therefore eminently suitable for work on paper.
9. Does not pucker up like oil; does not crack or fissure; no retouching medium required or the need for "oiling out" as with oil painting.
10. No preparation required before beginning work.
11. Unaffected by acids and has protective qualities.

As may be expected, the process is equally effective for black and white finishing, and when one thinks that in many cases a mere transparent film is required to take off the death-like look in enlargements, that the work is done more quickly than it can be described, and that no visible trace is left of the means employed, it should prove most useful.

Those who have had any experience at all in finishing work know that the grain of the paper is a great factor. Matt papers with a fine grain are preferable to smooth ivory surface or glossy variety. Except glossy P.O.P. for dye-work, all glossy paper should be avoided, but if one is obliged to color on glossy with the medium, color all over as described, set aside until next day to harden, and then polish with a clean brush as used for cleaning silver; or warm the work in front of the fire or by means of a stove until the wax comes to the surface of the color work and leaves a gloss.

Although wax and turpentine are used in this process, it is not what is called encaustic, which is wax and color heated by means of metal palettes, a moderately hot iron being used to fuse the tints and make the result less flat in tone.

If you have a dark subject, *e. g.*, black dress against dark brown background, the picture can be varnished to give depth, the same as Raffaëlli colors can be varnished.

Some may say, why bother about another process when we have water-color which many find more permanent than oil-color? But portraiture in water-colors presents almost insurmountable obstacles if the demand is for a medium-sized head, carefully finished, with some pretence of flesh tone and a realistic likeness. From Rembrandt, who used washes of sepia, to our own Sargent, who has today a full palette at his disposal, and has produced masterly landscapes in the medium, the water-color portrait is missing, proving the process unsuitable. Therefore, the masterpiece for students to study is likely to remain practically unknown; this condition of affairs is largely contributed by the difficulty of using Chinese white.

Pastel is a colored dust laid dry on to a surface to which it scarcely adheres, and, when fixed, looks like distemper, and makes very little headway in the arts. Oil painting alone survives, but even that hardly fulfils the most modern requirements. First, in order to apply the color to paper or canvas with a brush, it is necessary to add ten times more oil than is requisite, and all the mischief comes from the excess of oil. Varnish, unless skilfully used, is apt to make an enlargement look cheap and "Whitechappelly"; a dead matt finish looks superior, and has been proved by experts to reflect more colored light than a varnished surface. It often happens to the finishing artist to have a print over-exposed; the background and clothes, when colored in water-color, appear passable, but the flesh is a tone too dark. Oil colors are objected to as shiny, though wanted for covering power. If, however, a wax medium is used to give a dead matt effect, the result

*From *The British Journal of Photography.*

is in keeping with the rest of the picture. Paint quality, which learners find difficult to acquire, is due to the peculiarity of oil and varnish; with cerate paste a quality is easily got, either a luminous transparent film of color, pearly translucent tints, or opaque color, without any messy appearance.

Much will yet be done in color plates and color-recording papers, but it is doubtful if they will give simultaneous contrasts to which the eye is subject, and we are not told the amount of time required to get results or how plates are to be modified for color; therefore it will be well to proceed on the lines indicated.

The claim put forward here is merely a newer, simpler, and more perfect vehicle for work on photographic paper, by which each worker in the field may more easily strive to hold his own in the peaceful struggle to achieve things of beauty.

Resistance of Ships

THE present theory of the Resistance of Ships is that this resistance is composed of four factors, viz., (1) Wave-making, (2) Frictional, (3) Eddy-making, and (4) Air resistance. Of these, the first three are water resistances, of which the two first are the most important and are always present to a greater or less extent, while the third is of relatively small importance in well-designed ships and can practically be eliminated. The air resistance is seldom large, but by no means is it always negligible.

WAVE-MAKING RESISTANCE.

Waves need energy for their creation and maintenance and this can only be got from the moving body. This drain of energy constitutes the wave-making resistance. In our study of stream line motions we saw that when a body moves through water it tends to create a wave crest at the bow and one at the stern, as well as a hollow amidships. In a ship-shaped form the crests at bow and stern are the most important. The principal waves so created move along at a speed equal to that of the ship, with their lines of crests at right angles to the line of advance of the ship, and form what are known as the transverse wave systems. Aft of the ship the two systems combine in such a way that a crest of the bow series coincides with a hollow of the stern series, and so there is very little wave motion left behind the ship.

Besides the transverse series of waves there are also oblique or "divergent" series, as they are termed. These are formed at the bow and stern, and their lines of crests are inclined aft to the motion of the ship. These move off in their oblique directions, clear of the ship and practically have no further effect. They are common to all forms, but are of relatively small importance as compared with the transverse series.

The principal factors governing wave-making resistance, in their order of importance are, (1) Length of ship, (2) Area of midship section, (3) Ratio between beam and draught, (4) Shape of midship section, and (5) Details of shape towards the extremities. Taking these factors in the above order we may say that, briefly,

(1) The greater the length the less the wave-making resistance.

(2) At moderate speeds a full midship section and fine ends are desirable; at high speeds a fine midship section and full ends.

(3) The broader and shallower the ship, the greater is the resistance.

(4) With a given area of mid-ship section, and beam remaining constant, the shape of the section is practically immaterial.

(5) Generally speaking, U-shaped sections are best forward and V-shaped sections aft.

The greatest contribution to our knowledge of wave-making resistance is the practical outcome of the law enunciated by the late Mr. W. Froude, and spoken of as Froude's Law of Comparison. Mr. Froude pointed out that if there are two vessels, a large and a small, of which the smaller is an exact model of the larger, and these two vessels are run at speeds proportional to the square roots of their lengths the wave patterns produced are absolutely identical to scale. Thus, if the large ship is 16 times the length of the model, the pattern of the waves at 20 knots in the big ship is precisely the same as that for the model at 5 knots. Mr. Froude also showed that if the vessels were run at these speeds—known as "corresponding" speeds—the wave-making resistances are directly proportional to the displacements. As the displacement of similar ships is proportional to the cube of the length, in this case the resistance of the large ship at 20 knots would be 4,096 times that of the small model at 5 knots.

In order to prove this law Mr. Froude towed a full-sized ship called the *Greyhound* and measured the force in the towing line, and, after eliminating the frictional resistance, compared the wave-making resistance with that determined by towing a model of the ship at the corresponding speeds.

This Law of Comparison forms the basis of model experiments on ship forms. By running the model in an experimental tank and measuring its resistance it is possible to calculate the resistance of the full-sized ship at the corresponding speeds. Also, by dealing with models, alterations or modifications in form are very easily made and the best shape found for any particular boat. The models used in experimental tanks are usually made of paraffin wax, and thus lend themselves readily to slight modifications. The resistance measured is the sum of the frictional and wave-making resistances. From this the frictional resistance has to be deducted. This will be dealt with later. The remainder is usually spoken of as the "residuary" resistance, and to this Forude's Law of Comparison is applied to obtain the wave-making resistance of the full-sized ship.

So much experimental work has been done upon models that, from the published results of such experiments, it is now possible to design a ship of good underwater form for small resistance and to calculate this resistance, except in cases of ships of unusual forms. For the best results, however, after the design has been worked out along the lines indicated from the published results, a model should be made to the proposed lines and this model run in a tank. From its appearance and behavior under way it is possible for an expert investigator to suggest minor modifications in the lines that might cause an appreciable decrease in the resistance. When we consider that decreased resistance means less power for the same speed and consequently smaller and lighter engines and boilers, less coal and more cargo for the same size, it is evident that the cost of making such an experiment will be saved many times over and the ship-owner should be only too willing to pay a small fee for such an investigation.

FRICTIONAL OR SKIN RESISTANCE.

Water is not a frictionless fluid and in the passage of a ship through it there is a certain amount of drag on the particles touching the ship, which in turn communicate their motion to adjacent particles. There is thus a belt of water set in motion by the movement of the ship through it. This is called the Frictional Wake.

In the majority of ships skin resistance is the most important factor. Its evaluation is based almost entirely upon experiments made by the late Mr. W. Froude, who towed a series of thin planks endwise through water, the planks having been coated with various substances. The longest plank so towed was 50 ft., and when we consider that the results of these experiments have to be used in ship-shaped forms of vessels up to 900 ft. or so in length it is evident that there is a great need for further investigation into this important factor. It is assumed that the frictional resistance of the wetted surface of a ship is the same as that of a plane of the same length and area moving endwise through the water with the speed of the ship.

Froude experimented with surfaces of varnish, tinfoil, paraffin wax, calico and sand. The results showed that the frictional resistance may be expressed by the formula $R=fsv^n$ where R is the total frictional resistance, f is a factor depending on the nature or roughness of the surface, S the total wetted area, V is the speed and n the power of the speed according to which the resistance varies. For ships the value of n is about 1.83 and of f about .009 where S is in square feet and V in knots. This gives R in lbs. Thus, in a ship 330 ft. long, 42 ft. beam, 12 ft. draught and 2,200 tons displacement, the wetted surface is about 13,150 sq. ft. and the frictional resistance at 16 knots is about 18,415 lbs., or about 8¼ tons. The horse power required to overcome this at 16 knots is about 902, and this means something like 1,800 h.p. at the engines.

EDDY-MAKING RESISTANCE.

The motion of a blunt form, such as a square stern post, through the water gives rise to confused motions, or eddies, in the water in its wake. The resistance so caused is called eddy-making resistance. In a good design it is practically negligible.

AIR RESISTANCE.

This is only of importance in ships with large upper works. Mr. W. Froude made some experiments upon this. He found, in the *Greyhound*, that at 10 knots the air resistance was about 1½ per cent. of the water resistance.

RESISTANCE OF APPENDAGES.

Hitherto the ship has been treated as if she had no appendages, such as bilge keels, shaft brackets, etc. The resistance of these may be very appreciable. A merchant ship with a single screw will probably have little appendage other than the rudder and the appendage resistance will be something less than 4 per cent. of the bare hull resistance. On the other hand, a twin-screw ship with large bilge and docking keels may have an appendage resistance as much as 20 per cent. of the bare hull resistance.

RESISTANCE DUE TO FOULING.

In a slow-speed cargo boat the frictional resistance is the most important factor. We have seen that its value depends upon the nature of the underwater surface and hence the importance of keeping the bottom free from weeds, etc. Under the best conditions a vessel three or four months out of dock is liable to have an increase of 20 per cent. in the skin resistance.

DEPTH OF WATER AND SPEED.

Before leaving the subject of resistance mention should be made of the effect of depth of water on speed. It has been demonstrated that if a vessel is moving through shallow water, as her speed increases the resistance increases much more quickly than in deep water until a certain critical speed is reached, beyond which a higher speed can often be obtained with even less power, and any increase of speed beyond this calls for less increase of power than before. The reason for this phenomenon is that in shallow water the wave systems formed are shorter and steeper and absorb more energy than in deep water. But there is a speed for any depth at which these systems break down and give place to a single wave of translation that moves ahead with the boat and carries her with it. This phenomenon is usually accompanied also by a change of trim, the boat generally settling down a good deal by the stern.—*The Shipping World.*

The Bacterial Flora of Roquefort Cheese

THIS paper reports the study of the bacterial flora of imported Roquefort cheese as compared with the bacterial flora of experimental cheese of that type made in the Dairy Division of the Department of Agriculture. The experimental cheese differed from the imported in being made of cow's milk and ripened in rooms artificially cooled and moistened, whereas the imported cheese was made of sheep's milk and ripened in natural caves. The two varieties of cheese are very similar. The results of the study may be summarized as follows:

The microorganisms essential for the manufacture and ripening of Roquefort cheese are *Streptococcus lacticus* and *Penicillium roqueforti*. *Streptococcus lacticus* decomposes the lactose during the manufacture of the cheese and thus produces the lactic acid necessary for the cheese making. These organisms disappear from the cheese after about two or three weeks, being killed by the high concentration of sodium chlorid. The remaining flora of Roquefort cheese consists of cheese streptococci and *Bacterium bulgaricum*, organisms which are found in all kinds of ripening cheese. These organisms do not have any significant part to play in the ripening of Roquefort cheese.

The cheese slime consists of characteristic types of micrococci, rod forms, and yeast cells. The enzymes from the slime do not appear to be essential to the ripening of the cheese. The flora of both the interior and the slime of the experimental cheese was identical with the flora of the interior and the slime of the imported cheese.

If the maker of Roquefort cheese will inoculate properly with *Streptococcus lacticus* and *Penicillium roqueforti*, and provide the proper condition of manufacture and ripening, he need have no other concern about biological ripening agents.—*Note on a paper by Alice C. Evans in Journ. Agl. Res. 13:225, 1918.*

Stability of Emulsions in the Constricted Tube and Marble Device for Anaerobiosis

IN the cultivation of anaerobic bacteria in a constricted tube with a seal of hydrocarbon oil, in which a marble was placed, it was found that when the tube was heated in boiling water and then cooled, the oil below the marble became opaque owing to the formation of a fairly stable emulsion with the water. Emulsions may be prepared in this way with water and various petroleum oils, chloroform, ether, benzene, xylene, carbon bisulphide, olive oil, and aniline. The stability of such emulsions when formed in an open tube by rapid cooling in ice water, is slight as compared with similar emulsions formed below a marble seal, *e. g.*, in the case of water and olive oil less than one day as compared with more than 61 days below the seal. The presence or absence of an air surface above the emulsion does not affect the stability, but a marble or other mechanical seal interferes with diffusion and thus prevents evaporation, and to this must be attributed the relatively greater stability of emulsions formed below such a seal.—*Notes in Jour. of Soc. of Chem. Ind. on an article by I. C. Hall in J. Phys. Chem.*

An Electro-Magnetic Alternating Current Rectifier

How It Can Be Made by the Amateur

By George F. Haller

THE writer after extensive experimenting with various types of electrolytic rectifiers using aluminum asymmetric cells has come to the conclusion that they are practically more bother than they are worth. If the cell is left standing for any great length of time the electrolyte will creep, thereby lowering the efficiency. With continual use the electrolyte requires constant renewal. The aluminum oxide also, on which the rectifying effect depends, must be frequently reformed. Aside from these relatively minor difficulties the output of an electrolytic rectifier is comparatively small due to the heating of the electrolyte. This heating is the most serious drawback to the use of this form of rectifier. It lowers the efficiency and the rectified electromotive force. While it may be possible to keep the cell cool by the introduction of cooling worms the experimenter will find that the electrolytic apparatus is at best a rather makeshift affair.

The following is a description of two different types of electro magnetic rectifiers that may easily be constructed for use in the amateur's laboratory. Either type is far more efficient than the electrolytic rectifier, and there is no limit to the amount of power which may be taken from it. While the work of constructing a magnetic rectifier is somewhat greater than that of constructing an electrolytic the amount of labor saved in maintaining the former will more than offset the additional work. The electro magnetic rectifier, moreover, is always ready to supply rectified current, and does not become less efficient with continual use as does the electrolytic.

The best efficiency obtainable with the electrolytic rectifier is about 75 per cent. The writer has seen electrolytic cells in use by amateurs who were not overparticular in removing incrusted salts caused by the creeping of the electrolyte which has a rectifying efficiency of from 10% to 20%. The efficiency of the magnetic rectifier proper without an auxiliary transformer is over 98%, and the total efficiency including the transformer loss is well over 90% even in apparatus constructed at home. While questions of efficiency do not as a rule trouble the experimenter who uses but comparatively small amounts of electric current, still the saving in power due to the higher efficiency of rectification will soon pay for the greater cost of constructing a magnetic rectifier.

The principles on which both the two contact type and the four contact type of rectifier described below operate is similar to the usual commutation principle of direct current generators. The rectifier is in reality a reversed telephone pole changer in which alternating current is led in and continuous current is drawn out. Contacts alternately make and break connection with the A. C. terminals synchronously with the reversal in direction of flow in the A. C. leads. The result is an unidirectional pulsating current. The current on the direct side has the same wave form as that on the alternating side except that there are no negative loops of the current curve. All the negative values are made positive.

Referring to Figure I, "A" is a permanent magnet pivoted at the center so as to oscillate. One pole "N" is arranged to be attracted by an alternating current electro magnet "B" having a laminated core and supplied from the source to be rectified. To one end of the magnet the contact key "K" is fastened so as to make and break the circuit as the magnet oscillates.

When the direction of the A. C. flow in the electro magnet is such as to produce a pole opposite in sign to the pole of the magnet, the latter is attracted so that contact is made at "K". Current then flows during a half cycle into the battery "C" in the direction of the arrow. When the current in the electro magnet reverses direction a like pole is produced and the magnet is repelled, thereby breaking contact at "K" and preventing current from flowing into the battery in a reversed direction. The spring "D" is added so that contact is broken at "K" before the current reverses, thus the spring breaks contact instead of the repelling effect of like poles. This is done to prevent the small amount of reversed current necessary to repel the magnet from flowing through the battery. The break should occur when the current is zero. The exact point of zero current, however, is rather difficult to determine since it may not be at the point of minimum sparking due to phase displacement between the alternating current and electromotive force. In general, however, a slight spring tension just sufficient to overcome the hysteresis lag of the magnetic core will break contact as the current passes through a zero value. A small condenser shunted around the break will prevent sparking and will not draw any appreciable current from the battery being charged.

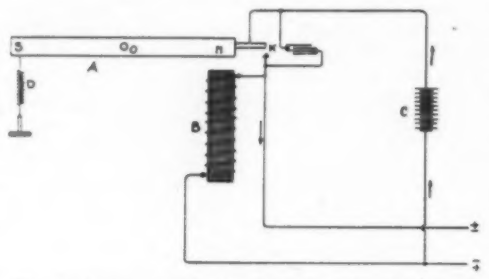


Fig. 1. Arrangement of oscillating magnet allowing A. C. to flow in one direction

Since the above arrangement uses less than one-half of the A. C. cycle, it might seem at first that the efficiency of this apparatus would be less than fifty per cent. That this is a common error is seen by an inspection of the literature on the construction of electrolytic rectifiers. A number of writers state that the single asymmetric cell which corresponds to the above arrangement has an efficiency of less than 50%. The single valve apparatus supplies unidirectional power for only one-half the cycle, but at the same time it draws alternating power for but half the cycle. What is meant is that current from a single valve cell flows for but half the time, and hence it requires twice as long to charge a storage battery as with the alternate path type of rectifier. The efficiency of the single path type is not less than half that of the alternate path type. With the single path type here is no true rectification. One loop of the alternating wave is allowed to flow through the battery being charged; the other loop is not reversed in direction but is only prevented from flowing into the battery. The action is exactly similar to a hydraulic check valve.

If an attempt is made to add a second contact to the arrangement in Figure I so as to use the other cycle and thereby obtain unidirectional current during each reversal of the source, an immediate difficulty is encountered—it is impossible to prevent a short circuit directly across the A. C. terminal without some sort of a transforming device. It is possible to use four contacts and obtain a true rectification, as shown in Figure II. This type of apparatus while doing away with a transformer has the disadvantage of having four breaks, thereby requiring four condensers.

Figure III shows the second method of obtaining true rectification. It has but two contact points but requires a neutral wire similar to the neutral in an Edison three wire system. When the amateur has alternating current supplied to him by the three wire system the arrangement of Figure III can be used. The rectified voltage will be a little less than one-half the voltage across the outside wires. A neutral can be obtained from a two wire system by using a choke coil or transformer, and since the amateur will in general require rectified cur-

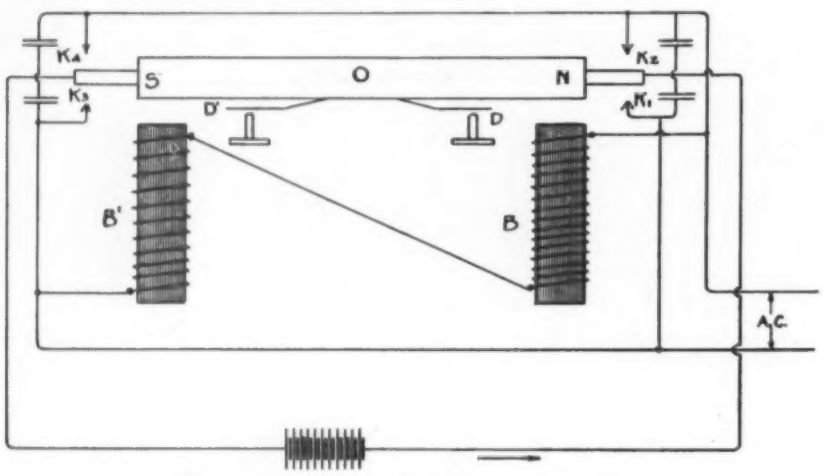


Fig. 2. Arrangement of four-contact rectifier

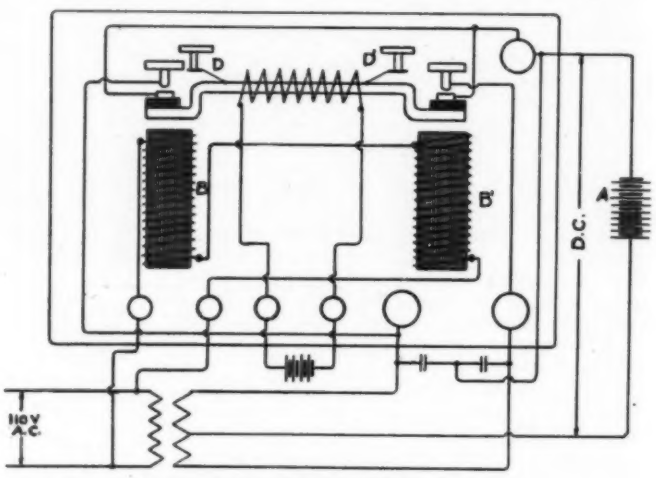


Fig. 3. Two-contact rectifiers with transformer

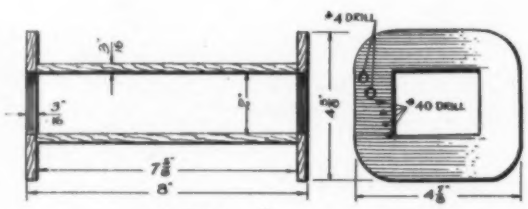


Fig. 4.

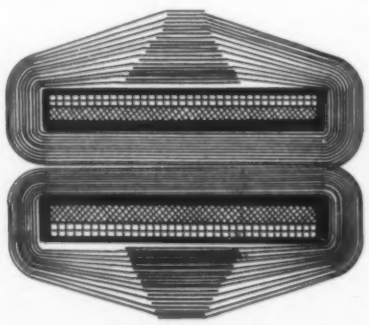


Fig. 5.

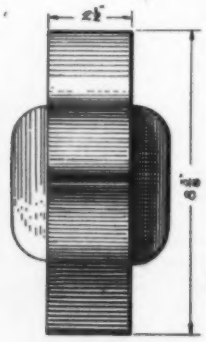


Fig. 6.

rents of a lower voltage than the supply pressure, a transformer and the two contact type of rectifier is to be preferred.

The following are the construction details of an electro magnetic rectifier of the two contact type, together

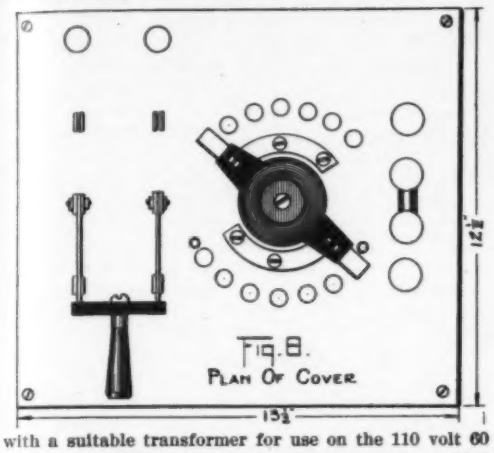


Fig. 8.
Plan Of Cover

with a suitable transformer for use on the 110 volt 60 cycle A. C. lighting current. The range of rectified unidirectional current is from five volts to one hundred and forty which is ample for most purposes. The capacity of the transformer is one-half kilowatt. The rectifier contacts are heavy enough for 50 amperes, so that more rectified power than 500 watts can be obtained from the rectifier directly across a three wire system. In this case the transformer is not used.

CONSTRUCTION OF TRANSFORMER.

The transformer is of the Ferranti type, which the writer considers to be best suited for homemade construction due to the fact that no corner joints have to be made, thereby not requiring the use of bolts.

Core: The core is composed of soft iron (stove pipe) strips 26 inches long and 2½ inches wide. They should be about 27 gauge or thinner. Enough should be obtained to make a compressed pile 2 inches thick. A strip of tissue paper should be inserted between each sheet.

Bobbin: A wooden bobbin to contain the primary and secondary windings is constructed of pieces of

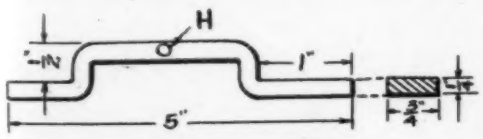


Fig. 14.

3/16" wood held together by glue and brads, as shown in Figure 4. Holes should be drilled in both bobbin heads to bring out the ends of each layer. There are six holes in each head (Fig. 4). They are to be drilled along the narrow (4 3/8") side of the heads so as not to be covered by the core when it is bent into place. Be sure the holes in both heads are on the same side of the bobbin, in order that the leads from both ends will come out on top. Mark the holes in one head 1-2-3-4-5-6, and in the other A-B-C-D-E-F, beginning from the inner edge.

Primary winding: This consists of two layers of 100 turns each of No. 11 d.c.c. magnet wire. Wind each layer separately, starting the first layer in hole "1" and bringing the end out through "A." The beginning of the second layer should project through hole "2," and the end through the hole "B."

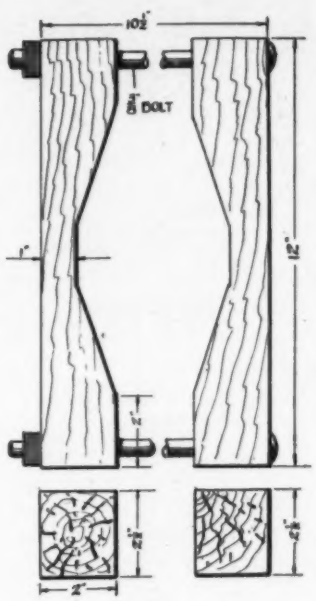


Fig. 7.

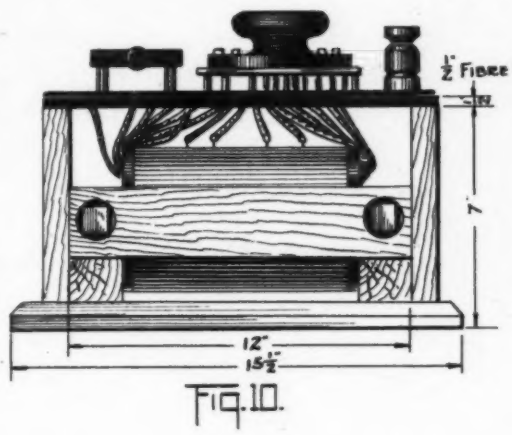


Fig. 10.

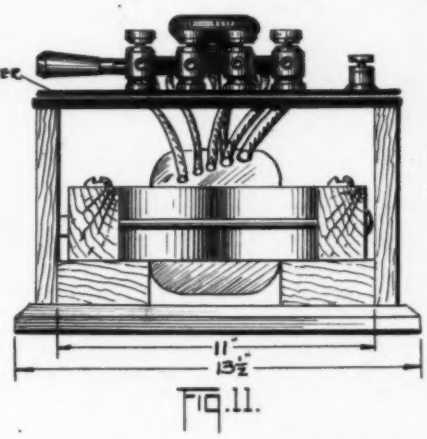


Fig. 11.

Secondary winding: This consists of four separate layers. Over the primary wrap several turns of heavy paper and wind on two separate layers of 100 turns each of No. 14 d.c.c. magnet wire, starting the first layer in hole "3" and ending in hole "C"; and starting the second layer in hole "4" and ending in hole "D."

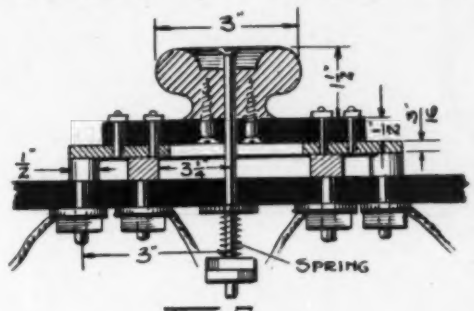


Fig. 9.
Section Thru Dial Switch

A tap should be made from the middle point of each layer on the same side of the coil as the holes in the heads, by soldering on to the wire a strip of sheet brass ½" wide and 2" long. These taps project between the turns of the outer layers and should be staggered and taped to prevent shorting. The coil is taped and two separate layers of 40 turns each of No. 6 d.c.c. magnet wire are wound on, beginning in holes "5"-"6" and ending in "E"-"F" respectively. Taps are made from the 10th, 20th and 30th turn of each layer. These taps should be brought out on the same side as the ends of the layers.

When the secondary winding is complete the whole coil can be taped and wound with cotton string, and given several coats of orange shellac.

The iron strips of the core should be bent up one at a time. It is well to tear away a portion of every other piece of tissue paper between the strips so as to make better magnetic contact. The transformer is mounted in a wooden box with a cover cut from ½" black sheet fiber as shown, and leads are run from the taps and coil ends of the secondary to the dial switch on the top of the box.

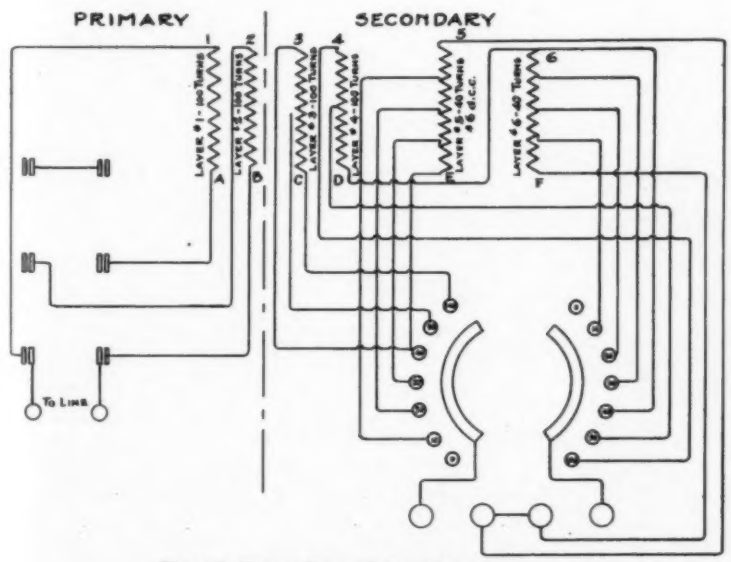
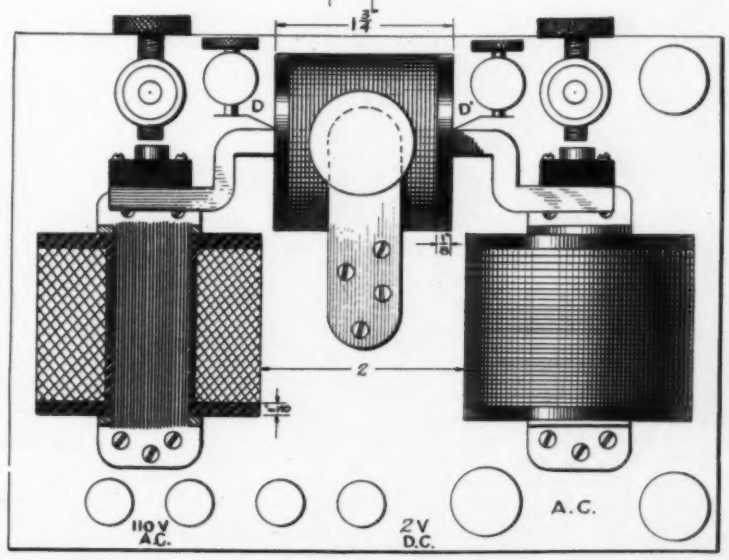


Fig. 12. Connections of transformer

Fig. 13.



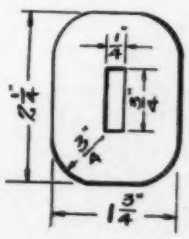


Fig. 15.

The primary terminals are connected to a double pole double throw switch as shown. The box can be filled with oil, or the transformer can be air cooled, in which case it is well to bore several holes along the upper side of the box to allow circulation of air.

The primary coils are normally to be operated in series, but for increased voltages they may be connected in parallel. The design is such that parallel operation will not produce too high a flux density in the core. This transformer can be used without the rectifying device, and for this reason it is mounted separately. The secondary voltage can be varied from 5 to 75 volts across either of the outside terminals and the neutral, with the primary coils in series; and from 10 to 150 volts with the primary in parallel. The maximum voltage across the outside terminals is 300 volts.

CONSTRUCTION OF THE ELECTROMAGNETIC RECTIFIER.

The two contact type of rectifier will be described. If the four contact type is desired it is only necessary to make the oscillating armature longer and to add two additional contacts and condensers, and connect up as in Figure 2.

An electromagnet is used instead of a permanent magnet for the oscillating armature. It can be energized from the first cell of the battery being charged. If the rectifier is used for driving a motor or other such purpose, current from two dry cells will be sufficient to maintain excitation.

Alternating Electromagnets: Two electromagnets are required, having laminated cores composed of a bundle of iron wire, about No. 22 B. & S. The cores are ¾" in diameter and 2" long; about 3/8 lb. of straightened wire will be required for both cores. Two fiber heads ⅛" thick, 2¼" in diameter are required for each bobbin. The heads are to be placed ⅛" from either end of the cores. The magnets are wound with No. 24 d.c.c. magnet wire. About 1,270 turns are wound on each magnet.

The magnets are mounted on a hard wood base 5" x 7" as shown in Figure 13. They are held in place by brass angle pieces (Fig. 17) slipped over the projecting ends of the cores.

Oscillating armature: For the armature a piece of ¼" x ¾" cold rolled steel or iron is bent into the shape of Figure 14. A hole "H" is drilled in the narrow edge at the center of the bar, and a piece of ⅛" hardened Stubb steel 3" long is driven in to serve as an axis of rotation. Figure 16 shows the bearing supports with the armature core and axis, the lower end of which rests in a recess in a hardened steel plate screwed to the base; the upper end is held by a brass screw as shown.

Armature: The polarization of the armature is maintained by a coil of No. 24 d.c.c. wire wound as shown in Figure 13. Figure 15 shows the bobbin heads which are composed of ⅛" fiber. They are slipped on the bar after bending. No difficulty being encountered at the bends. The bobbin is wound full.

Two springs "D"-"D" cut from No. 26 sheet phosphor bronze are fastened to the bar by screws before starting the winding.

The movable contacts are carried at the ends of the armature and are insulated from it by hard rubber blocks. Heavy flexible leads from the contact are tied along the under side of the bar. They run to the center where they are soldered together and drop to a hole in the base, thence to the binding post as shown in Figure 3. Terminals from the magnetizing coil and the A.C. electromagnets are connected to binding posts in the same manner.

The stationary contacts consist of heavy brass screws at least ¼" in diameter mounted so as to make contact at each swing of the armature.

Adjusting screws are provided to press against the springs by means of which the aparatus is tuned up. The leads carrying current from the contacts should be at least No. 6 and the binding posts correspondingly large, if it is desired to draw a full ½ k.w. at five volts.

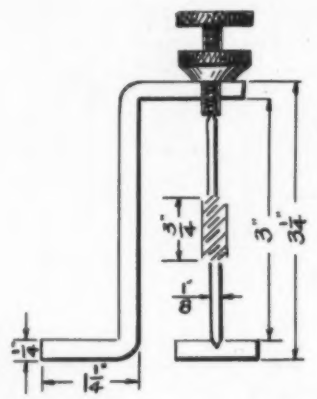
Two small condensers each composed of fifty sheets of tinfoil 4" x 6" shunted around the contacts will reduce all tendency towards sparking. The condensers can be mounted in the base so as to make the apparatus self-contained.

The Tonka Beans of Commerce

THE tonka tree (*Dipterix odorata*) yielding the tonka beans of commerce, one of the well-known forest trees of Colombia, Venezuela, Guianas and Brazil, is variously known also as sarapia, serrapia, tonca, tonqua and tonquin. It is sometimes incorrectly referred to as quiac a name given to an allied tree known to botanists as *Dipterix oppositifolia*, which is more or less important as a forest tree in the regions where the tonka gdows. There are two other species belonging to this group found in tropical America; one is the almendro or almond tree of Panama, which has recently been described as *Dipterix panamensis;* the other is the eboe nut tree of the Mosquito Coast, which is botanically called *Dipterix oleifera.*

The tonka tree finds its best development along the Caura River, a large tributary of the Orinoco in Venezuela. Reputable authorities reported that very extensive forests of tonka occur throughout the Vaura valley as far south as the Pacaraima Mountains, which form the boundary line between Venezuela and Brazil. Little is known regarding its occurrence in Colombia and Brazil, and it is only sparingly scattered throughout the forests of Trinidad and the Guianas.

FIG. 16.



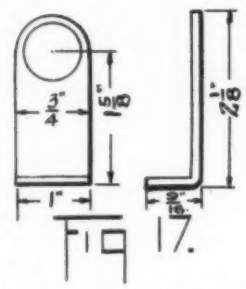


FIG. 17.

The tree is rarely cut for the wood it yields, and the chief reason for this is because the sound merchantable trees are usually back from the rivers in the depths of the forest far from any road so that the hauling or dragging out the logs would be an undertaking too costly to leave margin for profit on the investment. Another reason why the wood does not come into the market is because the fruit of the tree has a commercial value and enormous quantities are collected annually along the tributaries of the Orinoco River and shipped to European and American markets. Many Indians make a livelihood by collecting these fruits.

The tree reaches a height of 15 feet and upward to three feet in diameter. It has a straight, cylindrical trunk for more than one-half of its total height. The bark is brownish in appearance and slightly scaly. While the tonka has generally been described as occurring along the rivers and water courses, it is worth noting that it finds its best development on well-drained hillsides and is frequently seen to occur at an elevation of from 600 to 800 feet above sea level. It has been described as one of the most beautiful trees in tropical America. It produces large pink flowers in showy terminal panicles and is easily recognized in the forests during June, July and August when the tree is in bloom.

The wood is very hard, heavy, strong, tough and durable. It has a fine texture and is cross-grained and when freshly cut has a reddish-brown color turning darker with age. It can be split and worked only with difficulty, though its cross-grained character renders it attractive when polished. In this state tonka wood becomes very valuable for cabinet work and interior finish, and possesses an oil somewhat similar to that obtained from the seeds, which it is believed acts as a preservative to the wood.

The fruit is an elliptical flattened pod about two inches long and contains a seed which is known in the trade as the tonka bean. In the fresh state it is covered with grayish green hairs and impregnated with a peculiar oily fluid. When dry it is hairless and chocolate brown and is nearly similar to a mango, but the seeds or beans are shaped like an almond only they are somewhat larger and are covered with a shiny wrinkled black skin. The thin layer of pulp on the fruit is rather sticky and tasteless, but it is eaten by the Indians and others living in the region of its growth.

The seeds owe their value to a crystallizable principle known as cumarin which is fragrant resembling new mown hay; this crystalline substance is freely soluble in alcohol and insoluble in water. A similar substance is prepared synthetically on a large scale from salicylic aldehyde and is also obtainable from a good many different plants not at all related to the tonka tree. These beans possess considerable commercial value as a result of this fragrant constituent which has a widespread and ever increasing use in Europe and America as a flavoring material in articles of immense consumption, such as tobacco, snuffs, cigars, cocoa, ice creams, confectionery, fine toilet soaps, hair dressings, dainty cosmetics, flavoring extracts, etc. The oil expressed from the colyledons of the seeds has a clear yellow color and is used as a therapeutic in medicine. The pulverized seeds form an ingredient used in the preparation of sachet powders and for this the consumption will largely increase.

The value of the tonka beans varies greatly from year to year and the chief cause for the fluctuation is occasioned by the irregularity of the crop. The tonka tree like almost every other tree in the uncultivated state has its seed years. It seldom happens that there are two full crops in succession. One good crop may be expected every two or three years and when the crops are poor for two years in succession prices go up as high as $4 per pound. During the years of abundance the beans usually sell around a dollar a pound. In 1913, the year before the war, nearly 800,000 pounds valued at over a million dollars were imported. The center of the industry is in Venezuela along the Orinoco. Ciudad Boliver is the point where the Indians and others, *serrapieros*, sell their beans to local dealers who in turn sell to exporting houses in Port of Spain, Trinidad. There were 752,607 pounds of tonka beans valued at $427,055 invoiced at the American Consulate at Trinidad for the United States during 1917, and 107,263 pounds valued at $122,628 in 1916.

The Thermo-Locomotive

AT a meeting of the Union for Railway Technique in Berlin, Oberbaurat Müller, Dr. Lng., spoke on the first thermo-locomotive.

According to the report in the *Zeitung des Verein Deutscher Eisenbahnverwaltungen*, Diesel motors are used for driving these locomotives. After the reversing capacity of the Diesel ships' motors had been so perfected that as regards speed and safety they were not inferior to the steam engine, the next step was to try the Diesel motor with locomotives. Here, however, far greater difficulties were encountered than in the case of ships. These principally concerned the problem of starting, that is, the development of the greatest traction power while the locomotive is standing still. The starting is effected by compressed air, and as soon as the train has attained a speed of about 10 km. it is switched on to fuel.

The first locomotive of this description was built in the spring of 1913 in the workshops of the firm of Silzer Brothers, at Winterthur. Efficiency trials were made by the Prusso-Hessian State Railway Administration, which were suspended during the war owing to the defective conditions of a Diesel cylinder, and so far it has not been possible to carry them out to the end. An agreement exists, according to which the locomotive will be taken over by this Administration if the working capacity and economy are proved at the trials.—*Nord-deutsche Allgemeine Zeitung.*

A New Double Tariff Meter

A NEW form of double tariff meter is described by the *Elektrotechnische Rundschau* that has the advantage that the higher tariff does not come into action at certain predetermined times of the day unless the current happens to exceed a certain value at such times. The advantage gained over the usual forms of double tariff meters lies in the fact that so long as lighting load alone is taken the charges are made according to the lighting tariff, including such times as the load tariff is in force, so long as no power load is taken. Power load is charged at the lighting tariff at certain periods of the day and at the power tariff at other specified periods. The above results are obtained by using an electro-magnet to change from one recording train to another. This magnet contains two windings, one that is connected to the supply by a clock at such times when the power rate is in force. This coil is not strong enough to effect the change-over, which only occurs when it is assisted by the second coil that is connected in series with the main circuit. This second coil is adjusted so that the change-over takes place when the load current exceeds a fixed amount so chosen as to represent a change from pure lighting load to power load. It is an ingenious appliance which should prove useful under many circumstances.

Electric Welding for Shipbuilding

Lloyd's Chief Ship Surveyor's Views

GREAT interest was aroused on Tyneside last Friday evening by the lecture delivered, to a crowded audience of members of the North-East Coast Institution of Engineers and Shipbuilders, on "Electric Welding for Shipbuilding Purposes," by Mr. W. S. Abell, M.Eng., Chief Ship Surveyor of Lloyd's Register. The address was followed by a demonstration of electric welding.

Mr. Abell stated that the practicability of uniting iron and steel plates by means of electric welding appeared to have been demonstrated about 25 years ago, but it was some considerable time after that before it was suggested that that process might be suitable for use in repairing hulls and boilers.

Since 1911, the use of welding for effecting minor repairs had been very greatly extended, and in 1917 about 154 cases occurred, of which 140 were to the boilers and the remainder to the hull. Of the latter, six repairs were made to the stern-post, three to the rudder and five were miscellaneous, including one case in which a previously executed weld had proved to be defective.

In view of the favorable nature of the experience gained, it was suggested about 18 months ago that the time had arrived when a further step in advance might be made, and the process of electric welding adopted throughout the entire structure of a vessel. Before, however, such a course could be approved it was thought desirable that all the evidence bearing upon the question should be examined, with a view to ascertaining the capability of electrically welded joints to withstand structural stresses. Numerous experiments had been made to find the strength of electric welds in various combinations of plating, but these had nearly always been confined to the determination of the ultimate strength of the welded joints and, in a few instances, to their ability to resist bending. In these circumstances it was considered essential that, before any substantial progress could be made, reliable data should be obtained embracing an examination of as many as possible of the properties of electrically welded joints. The information available regarding the ultimate strength of such joints did not touch at all upon several of the principal problems to be solved before the adoption of electric welding could be sanctioned in ship construction. In particular, information was lacking concerning the elastic properties of welding and welded material and its ability to resist the alternating stresses to which vessels were subject. As was well known, the stress at which a material broke down under conditions of repeated stress, particularly if of an alternating nature from a maximum tension to a maximum compression, was very much lower than the ultimate strength as measured in the ordinary way, and the behavior of welded joints under such conditions was a question of considerable importance in its relation to shipbuilding.

In devising tests on material of that kind it was not possible to reproduce exactly the conditions which would be experienced in actual practice, and the object aimed at was, therefore, to arrange a series of experiments which would demonstrate the average reliability of the welds under various conditions of loading. Another source of possible difficulties was that there was not, at least at present, any known method of testing the soundness of a weld after completion. In engineering structures it was nearly always possible, by examination of the finished work and by suitable mechanical tests, to determine whether the workmanship and material were satisfactory and reliable, and the fact that tests were not possible with welding rendered it all the more necessary that the preliminary experiments should be as thorough as possible. It was found necessary to design several methods of investigating the problems involved. It was decided that the experiments should include a determination by different methods of the modulus of elasticity and the elastic limit of the welding and welded material, together with the incidental information regarding the ultimate strength and elongation of the welded joints. A series of alternating stress tests with different forms of specimens tested under various conditions was also devised, together with a number of minor tests, including bending and impact. Complete chemical and microscopic analyses of the welding and welded material were made to ascertain the changes in chemical composition and crystalline structure produced during the welding process.

As a proportion of the stress in a ship which would be borne by the welded joints was largely dependent upon the relative values of the modulus of elasticity of the weld and that of the adjacent plating, it was thought desirable to examine that relationship in specimens as large as practicable, and test pieces were prepared of the maximum size that could be tested in a 300-ton testing machine, that being the largest power available. The length of the specimens was 6 ft. clear between the holders, while the breadth varied from 48 in. to 22 in., according to the thickness of the plates. Loads, increased gradually, were applied and the extensions under these known loads were carefully measured, by the strain meter designed by Dr. Montgomerie, at the weld and at various points on the solid plate adjacent to and well clear of the weld. The general conclusion to be drawn from the tests was that there was little or no difference between the modulus of elasticity of the weld and that of the plating. Other tests appeared to confirm that conclusion. In all the tests it must be recognized that the measurements were taken on specimens containing only a relatively small amount of the deposited material forming the weld. To obtain further information regarding the properties of that deposited material, small test pieces were prepared entirely composed thereof, and the modulus of elasticity thus determined was found to be 11,700 tons per square inch, as compared with about 13,000 tons for mild steel and 1,000 tons for wrought iron.

Afterwards the large butt-welded specimens were tested to destruction to ascertain the ultimate strength of the welded joints and, as the most common form of joint in shipbuilding was the ordinary overlap, a complete set of tests was carried out on joints of that form, while a few riveted overlaps were added to complete the series of comparative results. All these specimens were made as large as could be tested in a 300-ton machine. From the results it would appear that the tensile strength of a treble-riveted overlap was about 65 to 70 per cent., that of the unperforated plate; that of the welded overlaps from 70 to 80 per cent., and that of the butt welds from 90 to 95 per cent.

Two methods of carrying out alternating stresses were employed, in the first of which the specimens tested were in the form of round bars, while in the second they were in the form of flat plates. The apparatus used in the former case was a modification of that used by Wohler in his well-known experiments. The fracture in the case of the welded bars always took place at the weld. From the results of the tests it might be inferred that the welded bars would withsand a very large number of repetitions of alternating stress (say 5,000,000) with a range of 6 tons per square inch tension to 6 tons compression; the corresponding figure in the case of the unwelded bars was about 10 tons per square inch. In the case of the flat plates it would appear that the stress at which the butt-welded specimens were able to endure a large number of alterations was about 70 per cent. of that borne by the similar plain plate; the corresponding figure for the comparative endurance of lap welds and riveted laps was about 60 per cent.

The chemical composition of the material of the electrode was, obviously, a matter of primary importance in securing a satisfactory weld, and special care should be devoted to the selection of the material in order that the elastic properties of the structure might be preserved as far as possible. For special types of work the use of various alloys had been proposed, but for structural work it would probably be found that the most favorable results were secured by the use of an electrode with a composition similar to that of mild steel. If the composition of the weld were examined it would be observed that the carbon, silicon and manganese were almost oxidised away from the filling-in material during the process of welding, while the sulphur and phosphorus remained nearly the same, the deposited material being practically pure iron. One of the chief causes of the unsatisfactory welds sometimes obtained was the oxidation of the original and filling-in material. The possibility of trouble arising from that source was, to a certain extent, lessened by the presence of the silicon and manganese which, especially the latter, were powerful reducing agents. In America, advantage was taken of that fact in the manufacture of the bare wire electrodes, which were the common type in that country, by using a steel which contained an increased percentage of manganese. In this country bare wire electrodes were not common, most makers using a coating of some kind, the object in each case being to protect the molten electrode from oxidation. These coatings might be divided into two classes, those which volatilised at the temperature of welding and those which formed a liquid slag which finally solidified on the surface of the weld.

The advances which had been made in the last 20 years in the micrographic examination of the structure of metals and, particularly, of the iron carbon alloys afforded a very valuable means of investigating the conditions existing at the junction of the original and the added metal and of determining in some degree of soundness of the weld. To secure a satisfactory weld it was essential that there should be a good diffusion of the fused metal into the work without any abrupt line of demarcation. It was also desirable that the temperature should not be excessive and that the effect of heating should be losalised as much as possible, to avoid undue disturbance to the structure of the original material.

In the spring of last year a series of tests was conducted at Washington to determine the relative efficiency of riveting, caulking and electric welding, using ordinary mild steel electrodes without any covering. The test specimens were, in all cases, about 36 in. in length by 9 in. in breadth and ¼ in. in thickness. The results obtained showed that the strength of a single-riveted joint re-inforced by edge welding was nearly equivalent to that of an ordinary double-riveted lap.

An examination of the results of these experiments showed that the tensile strength of welded joints was greater than that of riveted joints, and such joints might, therefore, be accepted as fully equivalent to the latter. The results of the elasticity tests showed that, in general, the combination of welded and unwelded material behaved practically homogeneously up to at least the elastic limit, a feature of considerable importance in relation to structural stresses. It was only when the result of the alternating stress experiments were considered that the question of the limits of application became a serious problem. These tests showed generally that welded material would not withstand a very large number, say, several millions, of alternations, if the applied stress was greater than about $+6\frac{1}{2}$ tons per square inch. The capability to resist alternating stresses was, of course, of the very greatest importance in shipbuilding materials, and would appear, for the present at least, to limit the application of welding to vessels in which the stress was not exceeded. The calculated stresses in ship structures were, in the case of large vessels, rather in excess of that figure, although, from such information as was available on the subject, it would appear that the stress actually experienced by the material in a ship was considerably less than that calculated under the usually assumed conditions. It was well, however, to proceed cautiously in the application of a novel method of construction like electric welding, and it would probably be wise to limit its application meantime to vessels of a length of not more than about 300 ft.

In designing the structural arrangements of a vessel the joints of which it was proposed to weld electrically, the time spent in arranging the various details of the structure would be well repaid. The first point to which attention might be drawn was the desirability of limiting the amount of overhead welding required to be done. It was not possible entirely to eliminate this feature, but, with care, its extent might be considerably reduced. One method of achieving that was shown on the lantern screen, illustrating a way of arranging the seams and butts in bottom shell plating. The butt straps were fitted on the outside and lightly welded to one of the plates before erection. After the plates had been placed in position, the principal strength weld was made downwards and the only overhead welding in the joint was on the remaining edge of the strap. Another slide showed how the same object might be attained in the case of the attachment of the centre keelson to the foundation plates of a single-bottom vessel. The seams of the side plating should be joggled with a good clearance between the joggle and the edge of the adjacent plate, the strength weld being applied to the upper edge of the seam, and a light run on the lower. Consideration of the methods of attaching two members at right angles to each other immediately raised the question as to whether connecting bars and the flanges of beams and frames might be omitted. As a rule, these angle bars and

flanges had no inherent merit, and were merely fitted for lack of a better method of attachment, but their convenience for purposes of erection was such that their use was likely to be retained in the meantime, except in a few instances where temporary lugs might be fitted to secure the members until the welding was completed. In such cases, the welding might take the form of a complete run on each side, or an arrangement of tack welding might, in some cases, be adopted in which the welds were fitted in short length spaced three times the length of the weld from centre to centre. The actual amount of welded material which should be deposited varied, of course, with the thickness of the plating and could only be determined by actual trial in each case. It would generally be found necessary to complete the welds in more than one run. It was also advisable that as much welding as possible should be done on the ground before the various members were erected in place, as the operators had then a much better opportunity of securing satisfactory results. The maximum spacing of the service bolt required during the process of erection was a matter which could only be decided after some experience had been gained with vessels of different sizes. It was essential that the spacing should be sufficiently close to enable the surfaces to be properly drawn together, since the welding did not possess any drawing power at all, and any neglect to have the surfaces well closed must be very prejudicial to the success of the structure. It was probable that the most economical arrangement would be found to be a combination of riveting and welding, but the whole problem was one in which there would be gradual development as experience was gained and new methods of erection devised.

Since, as previously stated, there did not exist any means at present of testing the soundness of a weld after it had been completed, it was necessary that the operators employed should be reliable and well trained in the manipulation of a system of welding used. In welding, however, as in many other engineering processes, very much could be done to avoid variations in workmanship by the introduction of suitable mechanical devices to assist the workman by improving the means of control over the work. Electrodes were nowadays manufactured with a high degree of uniformity and, in most sets of welding plant, provision was made to enable the density of the electric current to be varied with the size of the electrode. It was important that the instructions issued regarding the size of the electrode and the corresponding current should be carefully followed and that care should be exercised to see that the metal was properly deposited. In the meantime, it was very necessary that the work should be closely supervised during the process of welding and, if that were done, the possibility of serious failure was remote.

The improvements in electric welding had opened up considerable possibilities of its extended application in shipbuilding. For reasons he had given, it was improbable that, until some practical experience on a fairly large scale had been obtained, welding would be applied to the structural members of a vessel exceeding 300 ft. in length, but, even for smaller vessels, there was ample scope for the introduction of that system of construction. Work had already been commenced on a coasting vessel, about 150 ft. long, by Messrs. Cammell, Laird, and both Lloyd's and he had to thank Sir George Carter and the firm for the great help given to them in carrying out their experiments. Proposals had been discussed for the building of a number of other welded vessels, ranging from 86-ft. drifters to standard ships 300 ft. long. In addition, numerous propositions relating to the use of welding in the construction of bulkheads, casings, deck-houses and similar items not subject to the principal structural stresses had been considered and many adopted. The extent to which welding would be adopted in the future would, in the long run, be governed by its relative cost as compared with the present methods of construction, account being also taken of the saving in weight and consequent increase in deadweight capacity due to the elimination of many of the structural elements which would no longer be necessary. On the whole, it would appear to be safe to say that for vessels of moderate dimensions the use of electric welding would become increasingly common with possibilities of extension to vessels of larger size as experience was gained and further research led to a nearer approach to perfection in the process of welding. If they could have some experience in different directions and if the result of the application to small vessels should prove to be satisfactory, he thought there was no question that they should be justified in extending the process to larger vessels, and, at the same time, by the time that stage was reached, they should probably have learnt many details in the application of welding and in the design of details necessary for that purpose.—*The Electrician.*

Phototropy: The Action of Light on Crystals

THE term "phototropy" was introduced by W. Marckwald in 1899 to designate certain color changes observed in crystals, so far only of organic substances, but not in their solution. The phenomena have the general character of a phosphorescence; but we should not like to say which of the two terms, phosphorescence or phototropy, is the wider, and it is doubtful whether or not the phenomena are photochemical or merely physical. The anhydrous chloride of quinquinoline, Marckwald observed, forms crystals of a pale yellow color; exposed to sunlight, the color changes in a few minutes into green; placed in the dark the crystals slowly turn yellow again; and this change can be hastened by heating the crystals and by exposing them to the same green radiations which they emitted in the excited condition, or at any rate radiations longer than those used for excitation. There is thus thermotropy as well as phototropy; but most of the substances subsequently examined by H. Stobbe, Padoa, Senier and Shepheard (of Galway College), and others, are not phosphorescent in the ordinary sense, that is to say, they do not display a luminescence in the dark after having been illuminated, nor are they triboluminescent, *i. e.*, they do not glow under friction. But they obey Stokes' law, that the excitation requires radiations of shorter wave-length than the color called forth, while the reversal is favored by radiations of that color. To give another example, certain stilbene derivatives turn red-brown when excited by violet and ultraviolet rays, but reassume their natural yellow color when exposed to yellow and red rays; the latter change is, according to Stobbe, 1913, hastened by heating the crystals, the former hardly; whether or not the presence of oxygen was essential to the change, could not be decided. Various other observations seemed, however, to favor Stobbe's view that phototropy is confined to compounds capable of existing in several isomeric modifications, and especially to stereoisomerides. This view is not supported by the latest investigation of the problems by F. Weigert (*Zeitslhrift für Elektrochemie*, August 1, 1918, pages 222 to 237). Weigert studies the crystals of B-tetrachloro-a-ketonaphathalene in linearly polarised light with special respect to the crystallographic axes. The crystals form four-sided prismatic columns which are capped by truncated pyramids; the crystals are colorless, with a very faint yellowish tint, but turn red-violet when excited by violet or ultraviolet rays, and colorless again when radiated upon by yellow-green light. The observations with a Hilger quartzspectograph are difficult because the polarised light used for the observation itself excites the crystals. The absorption spectrum of the crystals varies much with the plane of the polarised light. Defining this plane by the direction of the electric vector which may be in the horizontal plane of the *a b* axis, or be the direction of the vertical *c* axis (the edge of the prism), Weigert found that the unexcited crystals showed two absorption bands at 395 and 375 $\mu\mu$ for the *c* direction, and an end-absorption at 420 $\mu\mu$ in the other case; the excitation did not affect the bands in the *c* case, but made them much stronger in the *a b* case, when a new band in the yellow-green also appeared; yet the color change was much stronger in the former case, which is very peculiar. The axial ratio was not altered by the excitation, nor did the X-ray examination of the crystals (after Laue) mark any change, and the solutions of the compounds hardly showed any bands. As the color changes occur only in the oriented molecules of a crystal, not in the irregularly grouped molecules of solutions, Weigert considers that the phototropic changes are physical and due to intramolecular displacements of atomic groups. But his arguments cannot be summed up in a few words, and he is quite aware that any energy absorption should increase chemical reactivity.—*Engineering.*

Exposing on Line Subjects

THE ideal negative of a black-and-white line subject should, of course, show quite transparent lines on a perfectly opaque ground, but these conditions seldom exist in the developed plate, and have to be arrived at by after-processes of reduction and intensification. As a rule it is impossible to avoid a certain amount of veiling or fog over the lines, and so a reducing or "cutting" solution is always necessary, but if the background is not black enough at the start it stands a chance of being so much further reduced by the cutting solution as to render it difficult to get enough opacity, even with a powerful intensifier. The best initial negative can only be secured by taking pains over the exposure. If the time is either too short or too long it is impossible to develop up to blackness, while, in the event of the time being too long, additional veil is thrown over the lines. The exposures must, therefore, be rather nicely adjusted, and at the first attempt it generally pays to make a trial set of exposures in strips. It must, however, also be remembered that we cannot get full contrast in the negative unless it exists in the original, and a black-and-white drawing will not show this full contrast unless it is sufficiently well illuminated. If the light is too dim the drawing will not really be black and white at all, but black and grey, and it will photograph as such, showing transparent lines on a grey ground, instead of a black opaque one. Good light is essential for this kind of work, and, given brilliant lighting and a correctly-adjusted exposure, it is quite possible to get a jet black ground that will need no intensification.—*Brit. Jour. Photog.*

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